

HERBICIDES IN A ROADSIDE MAINTENANCE PROGRAM

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There have been numerous papers presented over the years on the use of herbicides in roadside maintenance. The majority of these papers dealt with the technical aspects of application, the efficiency of certain chemicals or the costs of various operations. These technical details are important and are necessary in developing a herbicide program. Of primary importance however is the necessity of thoroughly understanding the objectives of such a program and its relationship to the overall roadside maintenance requirements.

Roadsides were maintained for many years without herbicides. Why then is it necessary to use herbicides in today's roadside maintenance program?

The answer can be found in the great expansion of the highway network that followed World War II, and the wider rights-of-way that are part of modern highway design. These have multiplied the problems of roadside maintenance to the extent that maintenance budgets have not been able to keep pace with the rising costs of labor and the increased roadside acreage to be maintained. In fact, it is no longer efficient, or perhaps even possible, to use hand mowing and trimming to the extent required by today's highway mileage.

Highway departments, facing a tremendously expanded maintenance program, found that herbicides made it possible to stretch their funds and forces. Broadleaf weed control was found to reduce the number of mowings required in those grass areas which had to be mowed and also improved the appearance of roadsides where higher growth was permitted. Grass under guide rail and around posts and signs could be eliminated thus making hand trimming unnecessary. Brush could be killed or controlled to maintain sight distance and required lateral clearance. Noxious plants such as ragweed and poison ivy could be killed. These operations were accomplished in the past by hand labor. The herbicides released manpower, previously used in mowing, trimming and brush cutting, to perform other essential maintenance work.

As the efficiency of herbicides was realized and programs expanded, mistakes and over-use unfortunately occurred. Instead of being considered in its proper perspective as another tool in roadside maintenance, there have been some mistaken impressions

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that herbicides are a cure-all and end-all to roadside maintenance problems.

This false concept, which persists in some quarters today, should be counteracted by both industry and highway officials.

However, the mistakes of a minority should not result in wholesale condemnation of the use of herbicides along highways. Many highway departments have utilized herbicides in such a way as to realize maximum benefits without disfiguring roadsides or damaging vegetation on adjacent property. Despite such efforts, problems do continue to exist, and it behooves all of us to take a long second look at our use of herbicides in roadside maintenance.

The following is an attempt to outline a comprehensive program for the use of herbicides on highway roadsides, keeping in mind the objectives of the program and the limitations of the herbicides. It is based on a number of years of experience in the use of herbicides on the roadsides of the state highways in New York State. We believe our program recognizes and takes advantage of the major benefits to be derived from herbicides without resulting in unattractive roadsides or arousing public criticism.

Broadleaf Weed Control

The principal objectives in broadleaf weed control are: (1) to reduce the amount of mowing required in areas normally mowed and (2) to obtain a neat appearance in areas where mowing, if it can be accomplished at all, is excessively costly.

Sight distance must be maintained for the safety of the traveling public. Drainageways should remain unobstructed if they are to function as designed. The use of herbicides to eliminate tall growing weeds from these areas is justified by safety, economy and appearance.

Treating medians and interchange areas with herbicides will reduce the mowing required and improve appearances.

Weed control spraying to a limited distance up steep cuts and back of guide rail on fill slopes where machine mowing is difficult, if not impossible, may allow these areas to remain unmowed without sacrificing either sight distance or appearance.

The benefits to be derived from weed control spraying beyond the rather restricted areas mentioned above is debatable and has resulted in some public opposition to broadleaf weed control. Generally speaking there is no real benefit to be gained by eliminating broadleaf weeds from all of our rights-of-way. It is our opinion that in many areas, maintenance costs can be reduced

without sacrificing appearances by allowing native vegetation to become established on our roadsides.

Brush Control

The term "brush" is quite non-selective and usually includes all woody plants from the low growing shrubs to young trees. It is obvious that tall growing brush crowding in on the highway, obstructing sight distance, choking drainageways and creating a possible snow drifting problem, is undesirable and must be removed. Stem-foliage spraying is usually considered the most economical way to kill undesirable brush. However, such application should be closely controlled, for indiscriminate spraying produces a "brown-out" of roadside growth which we all wish to avoid. This is not only contrary to the objectives of modern highway maintenance, but when it occurs brings on more public criticism than all other uses of herbicides combined.

To preserve the appearance of the roadsides, the New York State Department of Public Works has adopted a policy which prohibits spraying the foliage of woody plants in the State's rights-of-way when they are over two feet high. This so severely restricts this practice that brush control by foliage spraying is limited to that incidental to our weed control spraying. Taller woody plants that interfere with sight distance or lateral clearance are cut and stump-treated to prevent regrowth.

While this procedure is more costly than spraying the foliage we believe the additional expense is justified. Natural beauty has a definite economic as well as esthetic value. Roadsides which are brown with dying vegetation certainly do not invite vacation and tourist travel, an important factor in any state's economy.

Furthermore, subject to control, woody plants have a place on our rights-of-way. Native plants established on cuts and fills in rural areas create a natural appearance and reduce maintenance. Shrub and tree growth in wide medians produces headlight glare and increases the safety of the highway. Within the limitations set by sight distance, drainage, and highway location, selected woody plants should be retained on our highway roadsides.

Control of Vegetation Under Guide Rail and Around Posts and Signs

Hand trimming grass in the line of guide rail and around individual posts and signs is a costly, time consuming job. Treating these areas with herbicides to either eliminate all vegetation or to reduce the number of mowings required has become common practice.

The area to be treated should be limited to a strip two or three feet wide under the guide rail and to an area approximately three feet in diameter around individual posts. This will allow machine mowing without seriously hampering the efficiency of the mowers and does not result in an objectionable appearance.

The timing of the application is important if unpleasant appearances are to be avoided. Application should be made before growth reaches a height of six inches, otherwise the grass should be cut prior to treatment.

Growth Retardant

The use of growth retardants in roadside maintenance is relatively new and has not yet been developed to its full potential.

The primary purpose of applying growth retardants on roadside turf is to eliminate all or some of the mowing normally required. It has been our experience that it is economically practical to treat areas where mowing is difficult or hazardous. Such areas would include narrow medians on high traffic arteries and steep cuts and fills in urban areas.

Looking Ahead

We, in public service, highly value the contributions of the herbicide industry. Without the new techniques and products developed in recent years we could not have met the increased demands for our services that accompanied the expanded highway program. However these needs continue to grow, and to further assist roadside maintenance I would like to see the following developed in the near future:

Herbicides for broadleaf weed control which are non-volatile and in a form (dry or liquid) that is not subject to drift.

Application equipment that will efficiently apply a variety of materials such as granular products as well as liquids.

A growth retardant with a wider range of effectiveness, both as regards plant species and stage of growth.

Some form of continuing liaison between the major herbicide manufacturers and the various public and civic groups interested in their use. In addition, while we appreciate their efforts to date, we would like to see an increased awareness by herbicide manufacturers of their responsibility in recommending the proper use of herbicides to avoid adverse public reaction.

In closing I wish to emphasize the following points covered in this paper:

Herbicides properly used in a carefully planned and well executed program can release manpower, customarily used for mowing, trimming and brush cutting, for other essential maintenance tasks.

Prior to initiating any herbicide work on highway roadsides the objectives should be thoroughly understood and the program designed and executed to meet these objectives. Over-dependence on herbicides to solve all roadside maintenance problems can be blamed for most of the public's adverse reaction to the use of herbicides.

Increased emphasis must be placed on the appearance of the highway roadsides. We must recognize that the natural beauty of our roadsides is something to be cherished and protected.

THE USE OF SURFACTANTS TO INCREASE HERBICIDAL ACTIVITY

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Evolution of plant species has resulted in elaborate specialization of the cuticle which in part permits plants to grow in the frigid arctic and the blistering desert. The cuticle is not only effective in protecting the plant from many natural environmental conditions but is often an effective barrier against efforts to regulate or eradicate plants. Workers who have repeatedly had identical foliar herbicidal treatments to be effective one day and fail the next are likely to agree with Lee and Priestly (5) that the cuticle is "varnish-like." The cuticle often makes plants difficult to wet and impedes the movement of toxic quantities of herbicides into plants.

The degree of wettability or extent to which a herbicide spray can be spread over the surface of a plant is affected by (a) the degree of roughness of the plant surface, (b) the nature of the chemical groups at the plant surface, and (c) the presence or absence of an air film between the spray droplet and the plant surface (1, 3). It is not surprising that differences exist in wettability of different plants since tremendous differences exist in the chemical nature and physical make-up of plant surfaces (7, 8).

It has long been recognized that surfactants increase penetration of herbicides and other pesticides into plants. The voluminous and rapidly growing literature on increased herbicidal effectiveness due to surfactants has been reviewed by Currier and Dybing (2) and Jansen et al. (4). The mechanisms by which surfactants increase herbicidal activity are obscure and often controversial. Of paramount interest is that surfactants aid the entry of herbicides into plants and consequently increase the phytotoxic response obtained from a given level of herbicide. Therefore, this discussion will not consider modes of action but the increased herbicidal activity obtained by including a surfactant in spray mixtures. The data presented were obtained from the research programs conducted by the authors at the Delta Branch of the Mississippi Agricultural Experiment Station, Stoneville, Mississippi.

Much of the surfactant research at Stoneville has been concerned with 3,4-dichloropropionanilide (DPA), 2,2-dichloropropionic acid (dalapon), and 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron). Foliar sprays of DPA are used in the Mississippi Delta for the control of grasses in rice whereas dalapon is used primarily for Johnsongrass control. Dalapon is used as a preplanting treatment and is also extensively applied for ditchbank control and as a spot treatment in various crops in mid- and late-summer. Diuron is extensively used in cotton as a preemergence herbicide at planting and at the time of the last cultivation as a layby treatment. Recent developments have also led to the use of diuron-surfactant mixtures as foliar treatments. These treatments are applied as directed or semidirected sprays at the base of cotton plants.

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The effects of a surfactant on the herbicidal activity of DPA are shown in Table 1. In experiment 1 0.5% surfactant increased the grass control obtained with 1 lb/A of DPA by 42%. Similar increases in the control provided by 2 and 3 lb/A rates of DPA were also obtained. It is striking that 1 lb/A or 2 lb/A of DPA with 0.5% surfactant gave better grass control than DPA at 4 or 5 lb/A without a surfactant. DPA applied with a surfactant also gave much better control than DPA alone in the second experiment as shown in Table 1. Increased herbicidal activity of this type is important to farmers because use of the surfactant gives better control with 30 to 50% less herbicide than normally would be obtained without surfactant. Increased herbicide activity of this nature takes on more significance when it is realized that the difference in yield of rice following 60 rather than 90% grass control may be over 1000 pounds of rice per acre.

It was evident in initial studies with dalapon that the activity of this herbicide also was increased when a surfactant was included in the spray mixture. As shown in Figure 1 increased activity was obtained in greenhouse experiments with both technical and formulated grades of this herbicide. The magnitude of increased toxicity was somewhat greater with technical dalapon than with formulated dalapon as would be expected since the latter material apparently contains a surfactant.

An important aspect of field application of dalapon in the Mississippi Delta is the total volume of water in which the herbicide is applied. This is true since farmers may apply dalapon (a) in a volume of 5 to 10 gal/A by airplane, (b) 10 to 40 gal/A with a ground spray machine, or (c) 80 to 160 gal/A as hand applications for spot treatment control. Greenhouse comparisons of commercial formulated dalapon (Figure 2) and technical dalapon (Figure 3) showed that the volume of water in which treatments were applied influenced the activity of the technical dalapon more than that of formulated dalapon. The technical material was more effective at lower volume applications (10 to 20 gpa) than at higher volume applications and the greater effectiveness of the formulated dalapon was probably due to higher surfactant levels which resulted from the surfactant content of the commercial formulation. With both sources of dalapon it is noticeable that increased surfactant levels provided increased Johnsongrass control.

When a constant concentration of surfactant is used in spray mixtures, low volumes of total spray per acre cost less than high volumes. For examples, with a constant concentration of surfactant four times as much surfactant is applied at 40 gpa as at 10 gpa. Thus, on the basis of cost of surfactants in the Mississippi Delta the surfactant required to give a 0.5% concentration in 40 gallons of water will cost \$1.60 as compared with a cost of \$0.40 for 10 gallons of water.

The information that we have on dalapon-surfactant mixtures is helpful in aiding us to make better recommendations to farmers, but we have much to learn concerning the use of surfactants with dalapon. Additional information is needed to establish the relative importance of (a) the amount of surfactant applied and (b) the concentration of the surfactant solution. If the concentration (i.e. percentage of surfactant in solution) is of greatest importance

spray volume. If the amount of surfactant applied per plant (or per acre) is of primary importance the control obtained with a specific surfactant level should decrease in proportion to a reduction in volume. These considerations are not in agreement with the data in Figure 3.

Other possibilities are (a) that increased activity is a function involving interactions of herbicide level versus surfactant concentration or herbicide level versus surfactant concentration versus volume, etc., and (b) that neither the amount of surfactant applied nor the concentration considerations are straight-line functions.

The data in Table 2, obtained from field studies, also indicate that increased Johnsongrass control was obtained from formulated dalapon when additional surfactant was added to the spray solution. These data were obtained over a period of several months and under a variety of environmental conditions. Increases in control tended to correlate negatively with the rate of dalapon applied possibly because of the increased level of surfactant in the solutions of higher dalapon rates. If no additional surfactant were added, a 20 lb/A solution contains four times as much surfactant as a 5 lb/A solution.

In 1960 it was found that topical foliar sprays of diuron-surfactant mixtures were toxic to Johnsongrass. Further work in 1960 and 1961 demonstrated that these mixtures were even more toxic to young annual weeds and in some instances to more mature annuals. Farmers in the Mississippi Delta quickly adopted this practice and in 1962 treated nearly 300,000 acres of cotton with diuron-surfactant mixtures. Use of this practice has continued to increase in Arkansas, Louisiana, and Mississippi. Generally these mixtures are used in two different methods: (a) as an early-season postemergence spray directed to weeds underneath the cotton at the rate of 0.2 lb/A of diuron (0.06 lb/A on a 12-inch band) and (b) as a mid- to late-season broadcast treatment at a rate of 1.0 lb/A of diuron. The latter treatment is used to control weeds present at treatment and also for residual preemergence weed control. Effectiveness of these treatments is markedly reduced when weeds are growing slowly or under drought stress.

The effect of surfactant concentration on crabgrass control with diuron is shown in Figure 4. The optimum surfactant concentration was not reached at 1.0% with treatments of diuron at 0.02 lb/A. Diuron at 0.09 lb/A showed no increased toxicity from a surfactant concentration higher than 0.5% while diuron at 0.36 lb/A showed little increase in toxicity from surfactant concentrations above 0.25%.

Volume of diluent in which diuron treatments are applied has been found to exert an influence on the toxicity of low rates of the herbicide (0.02 to 0.09 lb/A) but has had little effect on rates of 0.36 lb/A or higher. It is possible that neither (a) the amount of surfactant applied nor (b) the concentration considerations mentioned previously are straight-line functions with regard to the phytotoxicity of diuron-surfactant mixtures.

Diuron-surfactant spray mixtures are obviously very phytotoxic when applied postemergence. These treatments should be economical for weed control in many situations. The cost of herbicide for applications of 0.2 lb/A as a directed postemergence treatment in cotton for example is generally less than \$0.70/A. When applied on the conventional band basis the cost is less than \$0.25/A. Even with the additional cost of the surfactant such treatments can be applied repeatedly without excessive cost. Band treatment with rates as low as 0.1 to 0.3 lb/A results in little chemical being applied to the soil even from 3 or 4 applications. Repeated applications of such small amounts of diuron does not result in a persistence problem in most soils.

Although diuron-surfactant mixtures are an important tool in practical weed control, comparatively little is known about these mixtures from a basic standpoint. Present data do not indicate that either surface tension or the Draves-Clarkson wetting test (Draves test) accurately measure the true herbicidal potential of these spray solutions (6). The pH of spray solutions, within a range of pH5 to pH9, seems to have little effect on phytotoxicity. Since many surfactants greatly reduce the turbidity of diuron suspensions it was previously assumed that the surfactant increased the solubility of diuron in water. This, as will be discussed later, is now known to be only partially true.

The authors have evaluated over 100 surfactants with regard to their influence in reducing the turbidity of diuron suspensions. The method used to do this was to mix and double filter various surfactant-diuron combinations. After adjusting a spectrophotometer to give 100% transmission on diuron-in-water (at the maximum absorption point of diuron in the ultraviolet region) the optical density was recorded for the surfactant (a) alone in water and (b) the surfactant plus diuron in water. The optical-density reading obtained from the surfactant alone was then subtracted from the optical density of the diuron-surfactant mixture. It is now known that the values so obtained are not representative of increased diuron solubility, but these data are nevertheless interesting (Figure 5). The data show that the reduction in turbidity of diuron suspensions is a function of both surfactant hydrophobe and hydrophil (ethylene oxide) content. Thus the optimum degree of ethoxylation depends on the hydrophobe used to form the surfactant. Even though the data of Figure 5 are indicative of increased light absorption (and defraction) but not indicative of increased diuron solubility, it is of interest that generally maximum light absorption (increased optical density values) for any surfactant group i.e., nonylphenol, is closely correlated with phytotoxicity of diuron-surfactant mixtures. Thus the greatest phytotoxicity is obtained with a nonylphenol surfactant mixed with diuron when the nonylphenol surfactant contains 10 moles of ethylene oxide or of a sorbitan mono tall oil surfactant which contains approximately 15 moles of ethylene oxide.

The ultraviolet spectrum of a diuron-surfactant mixture is presented in Figure 6. It can be seen that a typical diuron spectrum is obtained when no surfactant is added to the solution and that the typical diuron "curve" is no longer distinguishable after the surfactant is added. The curve obtained from the diuron-surfactant mixture is typical of that often obtained from a colloidal system. Additional evidence that diuron is not in true solution when mixed with surfactant in water is as follows: (a) clear diuron-surfactant mixtures exhibit the Tyndall effect and the degree of the Tyndall effect is affected by

very fine filter paper but a gelatinous precipitate is obtained if the mixtures are centrifuged at high speed (20,000 x gravity for 15 minutes). The spectrum of diuron cannot be distinguished before centrifugation but can be obtained after centrifugation. Additional work is needed to establish the chemical form of diuron when mixed with water and surfactants but it is likely that such mixtures are colloidal solutions and that the diuron is incorporated into the colloid micelles by the process of "solubilization." At sufficient concentrations in water many surfactants form molecular aggregates in the interior of the solution with the nonionized groups together and the ionized groups toward the water. When nonsurface-active molecules are added to such a colloidal solution they may enter the micelles and swell them so that a micellar solution will appear to "dissolve" a certain amount of the chemical which is relatively insoluble in water. Presence of colloids in diuron-surfactant mixtures means that the data of Figure 5 are a function of light absorption and deflection.

The toxicity of herbicides can be increased with additives other than surfactants (6). The data presented in Table 3 show that the toxicity of diuron can nearly be doubled by emulsifying 25% Diesel fuel into the spray mixture. Surfactant-herbicide research to date strongly indicates that we in the field of weed science know comparatively little about the influences of surfactants on herbicidal activity. Years of research with surfactants will be required before we can utilize our present herbicides to their maximum efficiency. Jansen et al. (4) found that many surfactants at certain concentrations may increase the activity of a herbicide on one species but not on another or that they may bring about specific suppression of herbicidal activity. This implication alone will require much work for thorough study but offers a distinct means of increasing crop selectivity without reducing weed control effectiveness.

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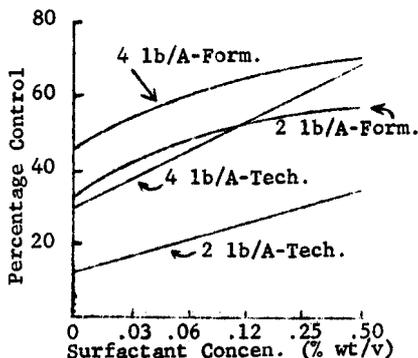


Figure 1. Percentage control of seedling Johnsongrass obtained with technical and formulated dalapon as affected by surfactant concentration.

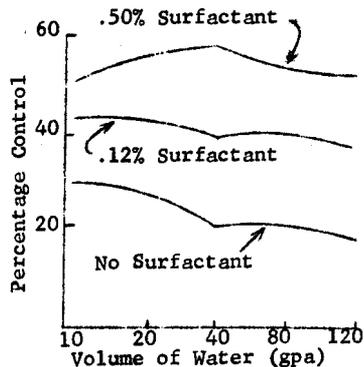


Figure 2. Percentage control of seedling Johnsongrass with commercially formulated dalapon as affected by volume of diluent and surfactant concentration. Plotted points represent control obtained with 4 rates of herbicide.

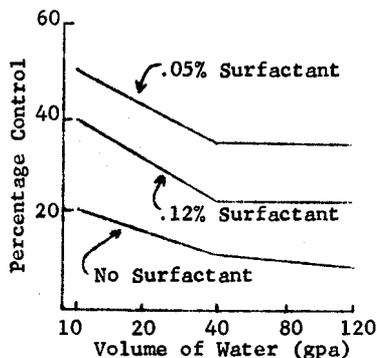


Figure 3. Percentage control of seedling Johnsongrass with technical dalapon as affected by volume of diluent and surfactant concentration. Plotted points represent control obtained with 4 rates of herbicide.

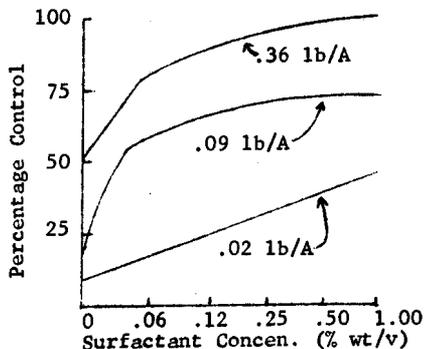


Figure 4. Percentage control of crabgrass with three rates of diuron as affected by surfactant concentration.

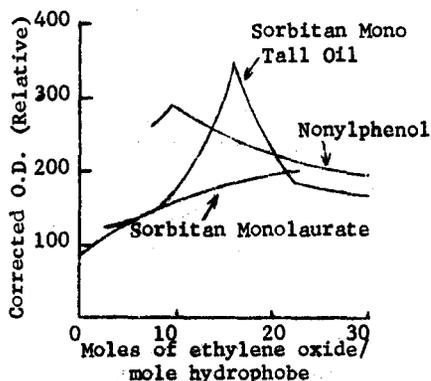


Figure 5. Relative optical density of filtered diuron-surfactant mixtures as affected by the surfactant hydrophil content.

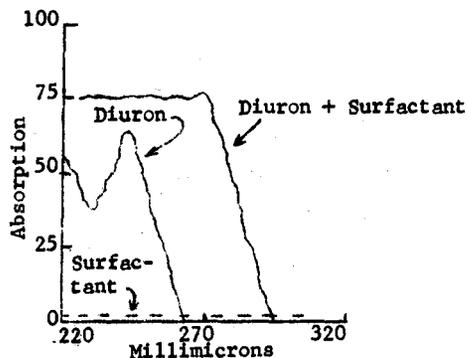


Figure 6. Ultraviolet spectrum of a surfactant (sodium lauryl sulfate), diuron, and a filtered diuron-surfactant mixture. Water was the diluent each instance.

Table 1. Percentage grass control in rice obtained with various rates of 3,4-dichloropropionanilide (DPA) as affected by surfactant concentration at Stoneville, Mississippi, 1962.

Herbicide (lb/A)	Percentage 1/ surfactant (v/v)	Percentage grass control	
		Experiment 1	Experiment 2
None	None	0	0
1	None	44	
1	0.25	39	
1	0.50	86	
2	None	41	65
2	0.25	89	85
2	0.50	94	90
2	1.00		90
3	None	46	75
3	0.25	95	95
3	0.50	91	95
3	1.00		95
4	None	70	
5	None	70	

1/ Isooctyl phenyl polyethoxy ethanol and nonyl phenyl polyethoxy ethanol were used as surfactants in experiments 1 and 2 respectively.

Table 2. Johnsongrass control obtained in 1960 and 1961 at Stoneville, Mississippi following the application of formulated dalapon with and without additional surfactant in the spray solution.

Experiment	Dalapon ^a lb/A	Percentage Johnsongrass control	
		Without additional surfactant	With additional surfactant ^b
1	5	60	65
1	10	70	68
2	5	65	75
2	15	85	83
3	5	60	75
4	5	58	75
4	20	88	90
5	5	50	73
6	5	60	80

^aTreatments in experiment 1 were applied at 100 gpa and all others at 20 gpa.
^bA polyoxyethylene thioether at 0.25 or 0.50% (wt/v).

Table 3. Crabgrass injury 14 days after treatment with various sprays at 20 gpa containing 1 percent ethoxylated sorbitan monostearate.

Percentage Diesel fuel	Diuron lb/A	Percentage Control	
		Topical sprays	Lateral sprays
5	.09	18	23
10	.09	18	20
15	.09	32	34
20	.09	20	58
25	.09	12	78
30	.09	20	73
5	0	0	6
10	0	6	21
15	0	6	20
20	0	3	25
25	0	11	36
30	0	16	53
0	.09 ^a /	41	34
0	.09 ^a /	53	42
0	0	0	0

^a/ ethoxylated nonylphenol used as the surfactant when Diesel fuel was not added.

PROMISING NEW CHEMICALS FOR WEED CONTROL¹James D. Riggleman²

The herbicide researcher of today is surrounded with many new and excellent compounds, products of the chemists unending search for better herbicides to benefit mankind. Twenty years ago we thought 2, 4-D was a miracle, now people are requiring such specificity as weeding morning-glories from sweet potatoes, horse nettle from tomatoes and crabgrass from bluegrass turf. Once we thought 2 weeks of weed control in field crops was marvelous, now we have compounds that will give full season control with a single application. Teamwork has made dreams become realities.

Short labor supply for hand weeding and increases in mechanical harvesters have intensified the need for efficient, specific herbicides. Farms concentrating on larger acreages of fewer crops have magnified our inherent weed problems. Concomitantly, there have been changes in other fields employing herbicides. As our standard of living progresses, so also do our utilities, public highways and recreational areas to say nothing of such leisure interests as backyard gardening. All of these are areas requiring herbicides for safe, economical, and efficient management.

A researcher now must, in so far as possible, investigate every phase known to him that may influence the efficacy of a herbicide. With the knowledge of a compound's structure and field behavior, keys are found to unlock patterns of herbicidal activity. Studying weaknesses of a compound as well as its strong points can be a valuable tool in combining compounds for improving overall efficiency. Combinations of herbicides continue to find places for strengthening certain facets of chemical weed control.

The discussion of promising new herbicides and new uses of existing herbicides is presented by structural categories. The discussion includes (1) strictly new herbicides; (2) those that have been in experiments recently to determine their full potential; and (3) new names or forms of established herbicides. Brevity, unfortunately, does not permit the discussion of many of the excellent herbicide combinations.

Benzoic Acid Derivatives

1. 3-amino-2, 5-dichlorobenzoic acid (amiben), Amiben or Vegiben, Amchem Products, Inc., Ambler, Pa.

Though not a new compound, amiben has been recently approved for use on tomatoes in a granular formulation known as Vegiben. Larger granule size

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reduces crop injury without reducing weed control. The product for agronomic crops, Amiben, is being tested for use in corn where there might be a residue problem to subsequent crops from other herbicides.

2. 2-methoxy-3, 6-dichlorobenzoic acid (diacamba), Banvel-D, Velsicol Chemical Corp., New York 1, N. Y.

Continued research demonstrates its use for brush control. Dicamba has recently been granted an experimental label for control of dog fennel in wheat at $\frac{1}{2}$ lb/acre.

3. 2, 6-dichlorothiobenzamide (SD 7961), Shell Chemical Co., New York 20, N. Y.

The structure of SD 7961 was made public this past summer. Although early work showed promise in some annual crops, it now appears useful on grapes, citrus, and bermuda turf at 4 to 10 lbs/acre and as a soil sterilant at 10 to 20 lbs/acre. The higher rates are necessary for effective post-emergence control.

4. 2, 6-dichlorobenzonitrile (dichlobenil), Casoron, Thompson-Hayward Chemical Co., Kansas City 41, Kansas.

An experimental label has been granted for the use of dichlobenil on cranberries, seed alfalfa and ornamentals. Control is obtained from 2 to 4 lbs/acre using the 4 G.

Phenylacetamides

1. N, N-dimethyl-2, 2-diphenylacetamide (diphenamid), Dymid by Eli Lilly and Co., Indianapolis, Indiana; or Enida by the Upjohn Co., Kalamazoo, Michigan.

Another compound with new uses is diphenamid. Seasonal weed control has been obtained in black and red raspberries from 3 to 5 lbs/acre. Late fall application on strawberries appears promising for winter weed control. If applied pre-emergence, chickweed, henbit, red sorrel and knawel are controlled. Chickweed is controlled by post-emergence applications of diphenamid. The 5 G shows promise for weed control in tomatoes.

Anilides

1. 3, 4-dichloropropionanilide (DPA), Stam, Rohm and Haas Co., Philadelphia 5, Pennsylvania

This post-emergence herbicide, introduced for grass control in rice, now shows promise in tomatoes and white potatoes. Applied after the weeds are up, but before they reach a height of 2 to 4 inches, it controls most grasses, lambsquarter and pigweed at rates of $\frac{3}{4}$ to 1 lb/acre. Further research continues on compatibility of the herbicide with certain other pesticides.

2. N-isopropyl-a-chloroacetanilide (CP 31393), Monsanto Chemical Co., St. Louis 26, Missouri

This is a new compound for use in corn and soybeans that shows a high specificity for annual grasses and certain broadleaved weeds at 4 to 6 lbs/acre. Its activity is somewhat similar to CDAA but is less susceptible to leaching.

Carbamates

1. isopropyl N-(3-chlorophenyl) carbamate (CIPC), Chloro IPC, Pittsburgh Plate Glass Company, Chemical Division, Pittsburgh 22, Pennsylvania.

This familiar compound now appears in a new formulation of a resin coated granule and has been used successfully for germinating dodder control as well as grass and broadleaf weed control in alfalfa.

2. methyl N-(3, 4-dichlorophenyl) carbamate (swep), NIA 2995, Niagara Chemical Co., Middleport, New York.

This carbamate shows both pre- and post-emergence activity. In contrast to many carbamate herbicides, the activity of swep is not improved by incorporation; in fact, incorporation is detrimental. Applied pre-emergence, 6 lbs/acre gave excellent broadleaf weed and grass control for about 6 weeks. Previously demonstrated to be effective for weed control in rice, corn, beans, cotton, sweet potatoes and carrots, it has shown promise as a directed spray in nursery stock including arborvitae and gladiolus. Post-emergence applications on corn, asparagus, carrots, onions and celery continue under investigation.

Thiolcarbamates

1. ethyl N-ethyl-N-cyclohexylthiolcarbamate (R 2063), Stauffer Chemical Co., New York 17, N. Y.

R-2063 was released just this year and appears promising on corn, several crucifers and legumes, safflower, sugar beets and tomatoes. When applied at 3 to 6 lbs/acre there was excellent weed control with no apparent crop injury.

2. n-propyl-di-n-propylthiolcarbamate (R 1607), Stauffer Chemical Co., New York 17, N. Y.

Though not new, this herbicide continues to show promise in soil incorporated treatments for nutgrass control or applied to a dry soil surface for annual grasses and broadleaf weeds. Although R 1607 is a close relative of EPTC, crops have a greater tolerance for R 1607 without any appreciable sacrifice in spectrum of weed control. Soybeans, sweet potatoes, peanuts and tomatoes are tolerant of rates effective in controlling weeds. Tomatoes are sensitive to pre-planting incorporation treatments of R 1607.

3. ethyl-1-hexamethyleneiminecarbothiolate (R 4572), Stauffer Chemical Co., New York 17, N. Y.

This compound was new last year and continues to show promise in rice and cereal crops at 2 to 4 lbs/acre. Tomatoes, sweet potatoes, several crucifers and blackeyed peas are tolerant of 4 to 8 lbs/acre. Many grasses, red root and lambsquarter are effectively controlled at these rates.

Terephthalic Acid Derivatives

1. dimethyl-2, 3, 5, 6-tetrachloroterephthalate (DCEPA), Dacthal, Diamond Alkali Co., Cleveland 14, Ohio.

This herbicide was introduced several years ago. Recent research shows that DCEPA has promise on cantaloupes if treatment is delayed until 4 to 6 weeks after planting. A new formulation was introduced this year that involves incorporating DCEPA on a plaster granule which can be formulated to release the herbicide at a specified rate. Limited use at lay-by on tomatoes this year indicates that the material works very well even under low soil moisture conditions. Continued research with DCEPA shows promise on lettuce, kale, collards, turnips, mustard, cress and carrots.

Substituted Ureas

1. N-(p-chlorophenyl)-N'-methyl-N'-isobutylurea (HS 95-1), BASF, Inc., New York 17, N. Y.

This compound is not strictly new but has been field tested further this year. At the present time it appears to have a place for pre- and post-emergence weed control in corn at 3 lbs/acre.

2. 3-(3, 4-dichlorophenyl)-1-methoxy-1-methylurea (linuron), Lorox, E. I. du Pont de Nemours and Co., Wilmington 98, Delaware.

Linuron is in its third year of extensive development as a pre- and post-emergence herbicide. It was cleared this summer for pre-emergence application on soybeans for oil, and corn for forage crops. Rates for loams and heavier soils are 1 to 3 lbs/acre. Linuron also appears promising on carrots and white potatoes.

3. N-4(p-chlorophenoxy)-phenyl-N', N' dimethylurea (chloroxuron), C 1983, Tenoran, CIBA Corporation, Vero Beach, Florida.

Chloroxuron is a new pre-emergence herbicide this year that shows promise on strawberries, carrots, celery, peas, soybeans, corn, and nursery crops of Pyrus spp., Erunus spp., Ribes, Rubus and gladiolus. Research completed to date shows residual activity of about 8 weeks with no carry over to succeeding crops.

4. N(3-trifluoro methylphenyl)N', N' dimethylurea (C 2059), Cottoran, CIBA Corporation, Vero Beach, Florida.

This new pre- and post-emergence herbicide, as the name implies, is intended primarily for use on cotton which tolerates 3 lbs/acre. It also

appears promising on sorghum. Extent of weed control is about 6 to 9 weeks from 3 lbs/acre. A synergistic effect has been reported where C 2059 and amitrole are combined in the ratio of 10 to 3. This compound has soil sterilant properties at 20 lbs/acre.

Toluidines and Toluidides

1. 2, 6-dinitro-N, N-di-n-propyl-a, a, a-trifluoro-p-toluidine (trifluralin), Treflan, Eli Lilly and Co., Indianapolis, Indiana.

Trifluralin is not a new compound, but, has been labeled recently for pre-planting soil incorporation in soybeans. Previous work has demonstrated its use on sandy soils where low solubility and low leachability aid in its effectiveness. Other crops where trifluralin shows promise are tomatoes, sweet potatoes, snap beans, lima beans, lettuce, many of the crucifers and many ornamental crops. In sandy soils $\frac{1}{2}$ lb/acre incorporated gives seasonal control.

2. 2-tert-butyl-2-chloro-o-acetotoluidide (CP 31675), Monsanto Chemical Co., St. Louis 66, Missouri.

The structure of CP 31675 was made public just recently. From 2 to 8 lbs/acre, depending on soil type, are necessary for weed control. Crops tolerating CP 31675 are peanuts, white potatoes, sweet potatoes, established legumes and woody ornamentals. At rates of only 1 to 2 lbs/acre pre-emergence, it appears to control nutgrass on light sandy soils. At higher rates it may be useful as a soil sterilant.

3. 2-bromo-6'-tert-butyl-o-acetotoluidide (CP 32179), Monsanto Chemical Co., St. Louis 66, Missouri.

New this year, CP 32179 shows promise for pre-emergence weed control in table and sugar beets, beans, sunflower, corn and strawberries at 2 to 4 lbs/acre. Soils high in organic matter or clay content may reduce the activity of the herbicide. Susceptible weeds are barnyard grass, wild oats, foxtail and pigweed.

Acetonitriles

1. trichlorophenylacetoneitrile (CP 522), Monsanto Chemical Co., St. Louis 66, Missouri.

Introduced last year, CP 522 continues to show promise for both grass and broadleaf weed control in corn at 2 to 4 lbs/acre. Although excellent weed control is obtained from surface applications, light cultivation does increase the effectiveness of the herbicide.

Pyridazones

1. 1-phenyl-4-amino-5-chloro-pyridazone-6 (HS 119), Pyramin as developed

by BASF and Pyrazone as marketed in this country by Amchem Products, Inc., Ambler, Pennsylvania.

Sugar beets tolerate pre- and post-emergence applications of HS 119 at 2 to 4 lbs/acre. Weeds including lambsquarter, pigweed, yellow rocket, barnyard grass, foxtail and crabgrass are controlled by 2 lbs/acre of the herbicide. Table beets, spinach, peas, potatoes and corn also tolerate rates of HS 119 sufficient for weed control.

Triazines

1. 2, 4-bis(3-methoxypropylamino)-6-methylthio-s-triazine (CP 17029), Monsanto Chemical Co., St. Louis 66, Missouri.

For several years CP 17029 has shown promise for weed control in safflower, peanuts, soybeans and cereal grains. Applied pre-emergence, snap beans tolerated 3 lbs/acre and sweet potatoes tolerated 5 lbs/acre while only 2 lbs/acre were necessary for both broadleaf weed and grass control. Post-emergence applications will control lambsquarter, Russian thistle and certain other broadleaf weeds but not grasses.

2. 2, 4-bis(isopropylamino)-6-methylmercapto-s-triazine (prometryne), Geigy Agricultural Chemicals, Ardsley, New York.

This herbicide is not new, but appears promising when applied post-emergence on carrots.

Picolinic Acid

1. 4-amino-3, 5, 6-trichloropicolinic acid, Tordon, Dow Chemical Co., Midland, Michigan.

Picolinic acid represents a new family of herbicide compounds. Though particularly effective against certain hard to control brush species, it has also been used in other crop-weed situations. For brush, 1 to 2 lbs/acre are sufficient for control of sassafras, locust, persimon and other root suckering species. In addition, most conifers, red and white oak, and maple are killed. In field crops of wheat, barley, corn, and oats it is used for field bindweed and Canada thistle control at rates as low as 4 oz/acre. Where drift is a hazard or for convenience of use, the 5 G or 10 G offers promising results. Excellent control of cactus in turf and sassafras in cemeteries was obtained.

Salts of 2, 4-D

1. oleoyl 1, 3-propylene diamine salt of 2, 4-dichlorophenoxyacetic acid, Dacamine, Diamond Alkali Co., Cleveland, Ohio.

This new salt of 2, 4-D possesses low volatility and high penetrability with the result that many resistant species of brush are more easily killed.

Ethers

1. 2, 4-dichlorophenyl 4-nitrophenyl ether (FW 925), TOK E-25, Rohm and Haas Co., Philadelphia 5, Pennsylvania.

FW 925 has been given the trade name TOK E-25. It continues to show promise on potatoes, peas, beans, carrots, onions and crucifers when applied pre-emergence at 3 to 4 lbs/acre. The spectrum of winter weed control can be broadened to include chickweed by combining CIPC with TOK E-25. Post-emergence control of small broadleaf weeds and grasses is obtained from 2 to 6 lbs/acre on onions, peas, carrots, turf, strawberries and direct seeded or transplanted cole crops.

Methylcarbamates

1. 2, 6-di-tert-butyl-p-tolyl-methylcarbamate (Hercules 9573), Azar, Hercules Powder Co., Inc., Wilmington 99, Delaware.

The structure of Hercules 9573 was released recently. This herbicide continues to show promise for crabgrass control in turf at 10 lbs/acre.

Compounds of Undisclosed Structure

1. UC 22643, Union Carbide Chemicals Co., New York 17, N. Y.

UC 22643 is a new herbicide that appears promising for pre-emergence and directed post-emergence weed control at 4 to 8 lbs/acre in corn, sorghum, soybeans, lima and snap beans, peanuts, carrots, white potatoes, tobacco, bluegrass and redtop. Soil incorporation reduces the effectiveness of this herbicide. Sensitive weed species are crabgrass, barnyard grass, pigweed, lambsquarter and smartweed. For post-emergence control weeds must be less than 3 inches in height. Research indicates that the herbicide is not persistent in the soil.

FATE OF HERBICIDES IN SOILS

T. J. Sheets, C. I. Harris, D. D. Kaufman, and P. C. Kearney ^{1/}

The ability of soil-applied herbicides to kill plants depends primarily on the concentration of active molecules available in the soil solution for uptake by roots. Any environmental variable, soil property, or process occurring in soil which alters availability influences herbicidal activity. Processes which change the structure of the active molecules usually modify or eliminate phytotoxicity. As the fate of herbicides in soils is understood more completely, the frequency of crop injury from excessive root uptake will be reduced, more uniform performance of herbicides in different soils will be maintained, and sporadic injury to sensitive plants grown in rotation with sprayed crops will be reduced.

Several processes which determine the fate of herbicides in soils are volatilization, adsorption, leaching, photodecomposition, chemical reaction, and absorption and metabolism by microorganisms and higher plants. One or two of these processes often predominate in effecting loss of a particular herbicide from soil. Properties of soils and of herbicides and environmental variables act directly and interact in many combinations to influence herbicidal activity.

For this discussion, herbicides will be classified arbitrarily into four groups based on the time usually required for inactivation in soils: (a) 0 to 3 weeks, (b) 3 to 12 weeks, (c) 3 to 12 months, and (d) more than 12 months. In such an arbitrary classification, a particular herbicide may fit more than one group. Placement of a herbicide in a group may depend on rate and method of application, adsorptive properties of the soil and of the herbicide, and environmental conditions after application. The persistence and fate of herbicides within groups will be discussed in terms of the processes causing inactivation and decomposition, and new information on the decomposition of a few herbicides will be presented.

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Herbicides Inactivated Within 3 Weeks

Inactivation and loss of herbicides which are active in soil for 3 weeks or less are attributable largely to three processes, vaporization, chemical reactions, and soil adsorption. However, microbial action and leaching may account for loss of a major part of a few such herbicides.

The rapid loss of methyl bromide from soil (within 12 to 48 hours) is assumed to occur largely by vaporization. Sodium N-methyldithiocarbamate [SMDC] and 3,5-dimethyltetrahydro-1,3,5-2H-thiadiazine-2-thione [DMTT] disappear from field soils within 3 weeks and usually in a much shorter time. SMDC and DMTT undergo rapid chemical reactions in soils giving rise to the toxic intermediate methylisothiocyanate [MIC] (1, 19, 35). MIC is volatile and also undergoes further reaction with water and yields innocuous products (1). Therefore, loss of SMDC and DMTT from soils occurs by chemical reactions and volatilization.

Adsorption of 1,1'-dimethyl-4,4'-bipyridinium salt [paraquat] and 6,7-dihydrodipyrido(1,2-a : 2',1'-c)pyrazidiinium salt [diquat] to soil is rapid and sufficiently complete to render these herbicides inactive (10, 20, 33). Some other herbicides may be rapidly inactivated by soil adsorption, particularly in organic soils. Although the herbicide molecules are present, inactivation occurs because adsorption limits the concentration in the soil solution, and plants do not absorb sufficient amounts for injury.

Disodium monomethylarsenate [DMA] is active mainly as a foliar spray, and at rates normally used it is not very active when applied to soil. Lack of activity of DMA in soils may be a consequence of unavailability to plant roots or inability of plant roots to absorb the toxicant.

Results of studies in California (14) indicated that 3-amino-1,2,4-triazole [amitrole] disappeared rapidly from many soils. Two weeks after application, amitrole was not detected in 26 of 55 soils; it was present in only trace amounts in six others. Recoveries from the other 23 soils ranged from 8 to 94 percent. Loss of amitrole was attributed to microbial action. Day et al (14) suggested that variations of the rates of decomposition among soils could be due to differences in microbial populations or level of microbial activity.

Ashton (4) also reported that the decomposition of amitrole in Yolo sandy loam occurred by microbial metabolism; but the presence of an unidentified product in both autoclaved and unautoclaved soil suggested a chemical reaction or formation of a complex. Carbon dioxide was the major decomposition product; but at least 13 others, one or more of which appeared to be resistant to further chemical change, were formed.

The metabolism of the sodium salt of 2,2-dichloropropionic acid [dalapon] was studied in crude soils, pure cultures of *Arthrobacter* sp., and isolated enzyme systems (13). In studies on the metabolism of dalapon-1-C¹⁴ and 2-C-¹⁴, copious quantities of C¹⁴O₂ were evolved from soil perfusion columns and pure culture systems containing dalapon-1-C¹⁴, whereas most of the labeled carbon from dalapon-2-C¹⁴ was incorporated in the cellular components of the microorganisms responsible for degrading this compound. This pattern would be consistent with the hypothesis that pyruvate is one of the first metabolites of dalapon. The hypothesis was further substantiated in a cell-free system. A partially purified enzyme system rapidly dehalogenated dalapon with the stoichiometric production of pyruvate. A proposed mechanism of dalapon degradation involves beta elimination and the formation of 2-chloropropene and alpha-chloro-alpha-hydroxypropionate as hypothetical intermediates.

Retention of ethyl N,N-di-n-propylthiolcarbamate [EPTC] is greater on dry soils than on wet soils (18), and weed control is often poor or mediocre when applications are made to soils near field capacity. The rapid loss of this herbicide from wet soils appears to be a result of rapid volatilization. Adsorption to dry soils probably prevents loss of EPTC vapors (6). Water in films surrounding soil particles may prevent adsorption of the relatively insoluble EPTC by competition for or shielding of the adsorption sites. Loss of EPTC by volatilization is apparently reduced by soil incorporation since herbicidal activity is increased by this practice (5).

2,6-Dichlorobenzonitrile [dichlobenil] persists for only a few days on the soil surface (9). Incorporation of this herbicide extends its persistence for several weeks. In experiments conducted in the Tropics, a delay of 4 hours between application and incorporation reduced herbicidal activity to half. Therefore, volatilization appears to be a major process effecting loss of dichlobenil from soil.

Herbicides Inactivated Between 3 and 12 Weeks

The longer a herbicide persists, the greater the probability that several processes are involved in its inactivation and disappearance from soils. Volatilization is important for some herbicides that persist for more than 3 weeks. The carbamates, for example, may be gradually lost from the soil as vapors, and yet they usually persist for several weeks. Isopropyl N-(3-chlorophenyl) carbamate [CIPC] persists longer than isopropyl N-phenylcarbamate [IPC], and the difference between rates of volatilization may be sufficient to account for the difference in persistence (3, 26). Rates of microbial decomposition may be important also.

Deming (15) investigated the volatility of 2-chloro-N,N-diallylacetamide [GDAA] from soil surfaces. Retention of GDAA by soil increased as percent organic matter increased. Losses increased as soil moisture increased. At low soil moisture levels, retention was greater at 38° than at 21° and 29° C. Deming suggested that the relation was due to competition between water and GDAA for adsorption sites in the soil and surmised that loss of GDAA from a visibly moist soil surface would be directly related to temperature, whereas loss from a soil surface that appears dry would be inversely related to temperature.

Although EPTC and dichlobenil are rapidly lost by volatilization from the soil surface, they remain active for several weeks when incorporated in the soil. Since incorporation probably retards volatilization, other processes such as microbial decomposition may become important.

Adsorption regulates the concentration of many herbicides in the soil solution. Equilibrium is approached rapidly, and the major effect of adsorption in the absence of leaching or other movement would therefore occur within a few hours after soil contact. However, desorption and adsorption of herbicide molecules would take place as water movement occurs and as soil-water levels shift. Although a rapid process, adsorption would continue to affect availability through its influence on leaching and perhaps vaporization and metabolism by microorganisms as long as the herbicide is present in soils.

Leaching and concurrent dilution in soils are major factors in loss of activity of some water soluble herbicides from soils. Rainfall patterns as well as total rainfall probably affect the extent of leaching. 2-Methoxy-3,6-dichlorobenzoic acid [dicamba] and N,N-dimethyl-2,2-diphenylacetamide [diphenamid] were leached more by water applied in 0.25-inch increments than by the same amount of water applied in 1-inch increments (13). In humid regions herbicides that are readily leached do not usually persist for more than a few weeks and often for a much shorter time.

Photodecomposition may account for loss of some herbicides from soils. Two prerequisites are essential for photochemical alteration of herbicides: (a) radiation must be absorbed by the herbicide and (b) the absorbed radiation must have sufficient energy to cause transitions in the outer valence electrons. If these two criteria are satisfied, a photochemical reaction may result. Infrared radiation has insufficient energy to cause such a reaction. The lower limit of solar radiation at the earth's surface is about 300 millimicrons. Therefore, for a herbicide to be inactivated on the soil surface by solar radiation, it must absorb in the visible, near ultraviolet, or middle ultraviolet above 300 millimicrons. Many herbicides absorb within this range. Photochemical alteration of 3-amino-2,5-dichlorobenzoic acid [amiben] was demonstrated on filter paper and in aqueous solutions (32). In five tests to determine the importance of photochemical inactivation of amiben on the soil surface, results were inconclusive (13). In two of the tests, evidence for photochemical inactivation was observed; in the other three, results were negative. Therefore, the importance of this process in the inactivation of amiben under conditions of use is not known. Photo-inactivation might partly explain the reduction of the herbicidal activity of amiben applied preemergence when water applications were delayed several days (11).

Metabolism by soil microorganisms is probably the major pathway of loss of organic herbicides which persist longer than 3 weeks, but exceptions probably exist. An adaptation of effective soil microorganisms is necessary for chlorinated aliphatic acid and chlorinated phenoxyalkanecarboxylic acid herbicides (7, 8, 13, 22). The time required for adaptation varies with molecular configuration and the organism involved, but may also be affected by some environmental factors. In one study by Audus (7) 14, 70, and 270 days, respectively, were required for detoxification of 80 percent of 2,4-dichlorophenoxyacetic acid [2,4-D], 2-methyl-4-chlorophenoxyacetic acid [MCPA], and 2,4,5-trichlorophenoxyacetic acid [2,4,5-T]. In these studies detoxification curves depicted (a) a lag phase with no appreciable change in concentration of herbicide followed by (b) a period of rapid inactivation. Curves of this shape are indicative of an adaptation process. The time required for adaptation, therefore, influences or partially determines the life of certain herbicides in soils.

Early studies of the fate of phenoxy herbicides in soils were limited largely to gross observations on loss of phytotoxicity with time. Recently, metabolic intermediates from the microbiological degradation of certain phenoxy compounds have been isolated and identified. The beta-oxidation of the side chain of certain omega-phenoxyalkanecarboxylic acids and member of homologous series of chloro-substituted phenoxyalkanecarboxylic acids by *Nocardia coeliaca* was demonstrated by Taylor and Wain (34). An alternative pathway for the degradation of 4-(2,4-dichlorophenoxy)butyric acid [4-(2,4-DB)] by cleavage of the ether linkage to form butyric acid and 2,4-dichlorophenol was proposed by MacRae et al (27). They isolated proposed intermediates from cultures of a *Flavobacterium*

Herbicides Inactivated Between 3 and 12 Months

Several organic herbicides persist for 3 months or more. For some of these a long lag period may be necessary for adaptation of effective soil microorganisms. However, extended lag periods do not seem to explain the persistence or time-concentration relations of several persistent, organic herbicides. Data and observations suggest that s-triazine herbicides are decomposed by naturally occurring microorganisms which require no adaptation (13). Also, adaptation may not be necessary for microbial breakdown of the phenylurea herbicides. One line of evidence which supports this contention is the time-concentration relations of the phenylurea and s-triazine herbicides in soils. The rates of inactivation and decomposition of these herbicides are a function of the concentration in the soil (21, 31). This relation suggests that the rate-limiting process is physical or chemical rather than biological. The slow breakdown and lack of population proliferation may be due to the effects of adsorption-desorption equilibria on availability for uptake and metabolism by soil microorganisms. To persist in the surface soil, these herbicides must also be relatively insoluble so that leaching and soil dilution effects are minimal.

Effects of adsorption-desorption equilibria may be too simple an explanation for slow breakdown since this concept suggests that phenylurea, s-triazine, and perhaps other herbicides are most persistent in soils high in clay and organic matter. Field observations often indicate that phytotoxicity several months after application is less in soils with high adsorptive capacities. However, distinction must be made between decomposition and inactivation. Decomposition involves chemical change in the herbicide molecule and usually the formation of inactive products. Inactivation means loss of herbicidal activity, which occurs by decomposition or by processes other than those leading to chemical change. Availability for uptake by plant roots can be reduced by soil adsorption and insoluble salt or complex formation; however, herbicides inactivated by these processes may be released slowly as the soil solution concentration is depleted by uptake by microorganisms, higher plants, leaching, and other factors. The rate of dissipation from soils might then be a function of the equilibrium between the adsorbed and solution phases.

The degradation of 2-chloro-4,6-bis(ethylamino)-s-triazine [simazine] by soil microorganisms has been studied at Beltsville (23). Aspergillus fumigatus, a common soil fungus, degraded this and several other s-triazine compounds. In comparative metabolic studies with C¹⁴ ring- and chain-labeled simazine, degradation by this fungus appeared to involve a dealkylation or deamination of the ethylamino substituents. Although utilization was apparent for both ring- and chain-labeled simazine, C¹⁴O₂ was liberated from only culture solutions containing chain-labeled compound. C¹⁴O₂ was evolved, however, from soils treated with ring- or chain-labeled simazine.

Benzoic acids such as 2,3,6-trichlorobenzoic acid [2,3,6-TBA] and 2-methoxy-3,6-dichlorobenzoic acid [dicamba] and phenylacetic acids such as 2,3,6-trichlorophenylacetic acid [fenac] often persist for several months in soils, but little has been published about the inactivation of these herbicides. Alexander (2) reported that 2,3,6-TBA, amiben, 2,5-dichloro-3-nitrobenzoic acid, and several other chlorinated benzoic acids were not significantly affected by mixed soil microflora in 60 days. Results of Dewey and Pfeiffer (16) suggested that 2,3,6-TBA was inactivated by soil microorganisms without population proliferation. In moist soil at 20°C., a large percentage of the 2,3,6-TBA applied became inactive after 2 or 3 months. The structure and charge status of these herbicides suggest that adsorption to soil would be of little consequence for preventing their movement with water. The benzoic and phenylacetic acids are more soluble in water than many other organic herbicides. Data of Phillips (28) showed that phytotoxic quantities of 2,3,6-TBA penetrated at least 5 feet in a silty clay loam. In studies by Dowler et al (17) 2,3,6-TBA and fenac persisted for at least 7 months in Coastal Plain soils.

Leaching and concurrent dilution in the soil, volatilization, and photodecomposition may reduce phytotoxicity and persistence of herbicides which are active for several months. Movement and dilution in soil may occur anytime during the life of the herbicide. Volatilization and photodecomposition are important when the herbicides are on the soil surface. Movement into the soil by rainfall or irrigation water or soil incorporation by cultural operations reduces or eliminates losses by volatilization and photodecomposition. Several s-triazine herbicides were volatile, and significant amounts disappeared from soil surfaces within a relatively short time at temperatures of 25 to 45°C. (24). Losses were much greater from metal surfaces than from soil surfaces. Loss of 2,4-bis(isopropylamino)-6-methoxy-s-triazine [prometone] from five soils was directly related to percent sand and indirectly related to percent clay and organic matter. Volatility of simazine and 2-chloro-4-ethylamino-6-isopropylamino-s-triazine [atrazine] was influenced less by soil properties than prometone. Mixing prometone with soil greatly reduced loss by volatilization.

Photodecomposition of 3-(p-chlorophenyl)-1,1-dimethylurea [monuron] in aqueous solution was demonstrated (21). Formation of colored compounds on exposure of the phenylureas (12) and amiben (32) on filter paper to light suggests a free radical reaction and polymerization. The relative importance of photodecomposition and volatilization in the loss of the phenylureas and the s-triazines has not been assessed.

Herbicides are absorbed by plant roots and many are subsequently metabolized. The importance of absorption and metabolism by higher plants as a pathway for herbicide loss from soil has not been established.

Herbicides Persisting for More Than 12 Months

Only a few herbicides, particularly inorganics such as arsenates, chlorates, and borates, remain in the soil in significant quantities longer than 12 months. These inorganic herbicides are generally used as soil sterilants rather than selective herbicides for crops; therefore, the prolonged persistence is usually beneficial. Sodium chlorate moves readily into soil in percolating water, whereas sodium arsenate is relatively immobile (30). Sodium tetraborate is less mobile than sodium chlorate, but leaching does occur. Low rates of application of these herbicides are ineffective against many plants because of low inherent phytotoxicity and soil adsorption, but at high rates of application they will control vegetation for many months. Leaching and dilution in soil, adsorption and fixation to soil, and formation of insoluble compounds and complexes are processes which bring about inactivation and dissipation from soils.

Residues of one experimental, organic herbicide or a decomposition product persisted in Norfolk sandy loam for 5 years in concentrations sufficient to cause severe malformations of tobacco. (25). Phillips (28) reported that 2,3,6-TBA persisted for 32 months in a silty clay loam soil; biological data indicated that the herbicide was present in greatest amounts at depths of 2 to 5 feet. Dowler et al (17) observed that 2,3,6-TBA and fenac at rates used to control witchweed persisted for at least 2 years in Coastal Plain soils. Some organic herbicides used for selective weed control in crops persist for 1 year or more under some soil and climatic conditions. Such herbicides sometimes cause injury to sensitive plants grown in rotations with the sprayed crop. Soybeans and sugarbeets may be injured in soil sprayed the previous year with atrazine for weed control in corn. This injury has been sufficient to cause concern, and farmers and researchers in sugarbeet-growing areas are looking for ways to eliminate or live with the small residue of atrazine that appears to cause trouble.

When organic herbicides applied at recommended rates for selective weed control in crops have persisted for 1 year, the concentration in the soil has been very low at the end of the year. In Canada, where environmental conditions favor a slower dissipation than in most areas of the United States, an average of 8.4 percent of simazine applied remained in the 0- to 8-inch soil depth for 1 year (29). With rates of application varying from 0.5 to 20 lb/A, the percent recovery 1 year after application varied from 4.5 to 14.4; the percent recovery was not related to rate of application.

The organic arsenicals are not very phytotoxic when applied to soil, but decomposition of these herbicides in soil must yield inorganic arsenic of some form. Inactivation of inorganic arsenic in soils occurs by fixation and leaching. Although the levels of

arsenic applied to the soil as DMA are low, the total arsenic level from organic herbicides and from other sources such as calcium and lead arsenate used for insect control in some crops become significant in some cropping situations.

SUMMARY

Herbicides were classified arbitrarily into four groups based on the time usually required for inactivation in soils: 0 to 3 weeks, 3 to 12 weeks, 3 to 12 months, and more than 12 months. The influence of volatilization, soil adsorption, leaching, photo-decomposition, chemical reactions, and absorption and metabolism by soil microorganisms and higher plants on the persistence and inactivation of herbicides in each of the groups was discussed. New information was presented on the metabolism of a few herbicides by soil microorganisms.

Attempts were made to relate persistence time to the nature and rate of the processes acting upon the herbicides. It was concluded that the longer a herbicide persists, the greater the probability that several soil processes will be involved in its inactivation and disappearance from soils.

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PRE-PLANT AND PRE-EMERGENCE TREATMENTS OF HERBICIDES
TO SNAP AND LIMA BEANS

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In New Jersey, approximately 7,000 acres of cropland are used for the production of fresh-market snap and lima beans. The annual monetary value of these crops is more than two million dollars. Due to their importance, weed control research has been conducted on these crops in New Jersey for the last three years.

Pre-emergence applications of DNBP, EPTC, and amiben have been some of the commonly used weed control chemicals. Research has been conducted on some of the newer available herbicides. Presently, the pre-plant method of herbicidal application is coming into prominence. This method has some advantages over the pre-emergence technique among which are ease of application, increase in herbicidal efficiency, and the decreases of climatic effect upon herbicidal activity.

Materials and Methods

Lima bean experiments were conducted from 1961 through 1963. A snap bean experiment was initiated in 1963. Harvest data were obtained only in 1963.

For the sake of brevity, treatments, varieties, dates of planting, application, observation, and harvest, and experiment location and soil type are presented in Tables 1 and 2.

The herbicides were applied with a bicycle or knapsack sprayer in water dilutions of 40 gpa. The pre-plant applications were only made in 1963 and were incorporated into the soil with a tandem-disc harrow. Pre-emergence applications that required incorporation were made by hand with a potato rake.

Each experiment was designed as a randomized complete block with three or four replications.

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Table 1. The effects of a number of herbicidal treatments on weed control, injury, and yield of snap beans in 1963.

Treatment	Rate, lb/A	Weed Control				Crop Injury		Crop Yields
		Broadleaves		Grasses		Stand ¹	Vigor ²	lb/A
		Stand ¹	Vigor ²	Stand ¹	Vigor ²			
Variety: Tendercrop								
Planted: June 5			Harvested: July 30					
Treated: June 5			Location: Adelphia, New Jersey					
Rated: July 22			Soil Type: Freehold Sandy Loam					
Ethyl di-n-propylthiolcarbamate (EPTC), 6 lb/gal								
pre-plant	4 inc.	9.0	5.3	8.3	4.0	0.8	1.0	3267
	6 inc.	9.5	6.7	9.3	7.7	1.4	2.3	3376
n-Propyl-di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
pre-plant	3 inc.	9.0	6.8	9.0	7.3	0.3	0.0	3557
	5 inc.	9.5	7.2	9.3	7.5	0.4	0.0	3593
Ethyl diisobutylthiolcarbamate (R-1910), 6 lb/gal								
pre-emergence	3 inc.	0.2	0.2	0.1	0.1	0.0	0.0	2461
	6 inc.	0.7	0.8	0.1	0.2	0.0	0.4	2440
pre-plant	4 inc.	6.9	2.7	7.0	4.7	0.0	0.0	3956
	6 inc.	7.0	2.5	7.7	2.7	0.0	0.0	3158
Ethyl-1-hexamethyleneiminecarbothiolate (R-4572), 6 lb/gal								
pre-emergence	3 inc.	0.3	0.0	0.0	0.0	0.0	0.0	2882
	4 inc.	0.9	0.0	1.3	0.6	0.0	0.0	3323
pre-plant	4 inc.	9.1	6.0	7.8	3.8	0.0	0.3	3194
	6 inc.	9.5	6.0	7.3	4.7	0.0	0.3	3086
3-Amino-2,5-dichlorobenzoic acid (amiben), 2 lb/gal								
pre-emergence	3	1.8	0.8	0.7	0.7	0.0	0.0	3344
4,6-Dinitro-0-sec. butylphenol (DNBP), 3 lb/gal								
pre-emergence	4-1/2	4.6	0.8	4.9	0.9	0.5	1.0	3471
N,N-dimethyl-, -diphenylacetamide (diphenamid), 80W								
pre-emergence	4	0.7	0.5	1.5	0.9	0.1	0.3	3176
	6	0.9	0.4	2.1	1.9	0.0	0.0	3807
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), 4 lb/gal								
pre-emergence	4	8.4	3.8	8.8	5.8	0.0	1.0	4396
	6	9.1	4.6	9.5	8.7	0.0	0.0	4711
pre-plant	1/2 inc.	8.5	1.3	7.7	4.0	0.0	0.0	2904
	1 inc.	8.9	2.5	9.0	5.7	0.3	0.0	3594

Table 1. (continued)

Treatment	Rate, lb/A	Weed Control				Crop Injury		Crop Yields lb/A
		Broadleaves		Grasses		Stand ¹	Vigor ²	
		Stand ¹	Vigor ²	Stand ¹	Vigor ²	Stand ¹	Vigor ²	
Dimethyl 2,3,5,6-tetrachloroteraphthalate (DCPA), 75W								
pre-	8	3.2	1.1	4.2	1.3	0.0	0.0	3113
emergence	12	5.4	0.9	7.1	2.6	0.0	0.0	2860
methyl N-(3,4-dichlorophenyl) carbamate (sweep), 2 lb/gal								
pre-	3	4.2	1.8	3.8	0.4	0.0	0.0	3533
emergence	6	7.3	3.0	5.7	2.2	0.0	0.4	3828
80W	3	3.2	1.1	3.1	1.2	0.0	0.1	2860
	6	7.8	4.7	8.1	3.6	0.0	3.3	4101
Sodium N-1-naphthyl phthalamate (NPA), 2 lb/gal								
pre-								
emergence	3	1.9	0.2	1.4	0.4	0.0	0.0	3576
Uncultivated Check		0.1	0.2	0.3	0.0	0.0	0.0	3008
Cultivated Check		7.6	2.2	6.7	3.1	1.0	0.0	3639

¹Based on scale 0 to 10; 0 = no effect, 10 = reduced 100%.

²Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

Table 2. The effects of a number of herbicidal treatments on weed control, injury, and yield of lima beans.

Treatment	Rate, lb/A	Weed Control				Crop Injury		Crop Yields lb/A
		Broadleaves		Grasses		Stand ¹	Vigor ²	
Variety:	Thaxter Baby Limas	Rated: July 7, 1961						
Planted:	June 2, 1961	July 27, 1962						
	June 11, 1962	July 17, 1963						
	June 5, 1963	Harvested: August 19, 1963						
Treated:	June 2, 1961	Location: Seabrook, New Jersey						
	June 14, 1962	Adelphia, New Jersey						
	June 5, 1963	Soil Type: Freehold Sandy Loam & Sassafrass Sandy Loam						
Ethyl di-n-propylthiolcarbamate (EPTC), 6 lb/gal								
pre-plant 1963	4 inc.	5.8	3.7	6.8	5.3	0.7	0.3	4755
	6 inc.	8.3	4.0	9.0	4.7	0.8	0.8	6315
n-Propyl-di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
pre-emergence 1961*	4 inc.	---	9.4	---	9.6	---	6.8	----
	6 inc.	---	9.5	---	9.6	---	6.8	----
pre-plant 1963	3 inc.	9.5	5.5	9.0	5.7	0.3	0.3	5808
	5 inc.	9.8	5.2	9.2	4.3	0.3	0.3	5227
Ethyl diisobutylthiolcarbamate (R-1910), 6 lb/gal								
pre-emergence 1963	3 inc.	0.3	0.1	0.0	0.0	0.0	0.1	1514
	6 inc.	1.6	2.3	1.3	0.3	0.4	0.3	2566
pre-plant 1963	4 inc.	7.0	3.7	3.3	1.3	0.8	0.5	2323
	6 inc.	7.3	4.7	3.0	0.0	0.3	0.0	4138
Ethyl-1-hexamethyleneiminecarbothiolate (R-4572), 6 lb/gal								
pre-emergence 1963	3 inc.	0.3	0.0	0.9	0.0	0.0	0.2	2166
	4 inc.	0.2	0.0	0.7	0.1	0.1	0.0	2293
pre-plant 1963	4 inc.	6.0	1.0	5.3	1.0	0.7	0.3	2940
	6 inc.	8.0	2.0	6.8	1.5	1.0	1.0	2141
3-Amino-2,5-dichlorobenzoic acid (amiben), 2 lb/gal								
pre-emergence 1961*	2	---	6.5	---	9.4	---	0.3	----
	4	---	10.0	---	9.9	---	0.0	----
1962	2	8.2	6.6	6.8	3.6	0.2	0.2	----
	3	7.0	3.8	7.6	5.4	0.0	0.0	----
	4	9.0	8.6	8.9	6.1	0.6	0.8	----
1963	3	3.9	1.3	2.8	1.3	0.2	0.3	3617

Table 2. (continued)

Treatment	Rate, lb/A	Weed Control				Crop Injury		Crop Yields
		Broadleaves		Grasses		Stand ¹	Vigor ²	lb/A
		Stand ¹	Vigor ²	Stand ¹	Vigor ²	Stand ¹	Vigor ²	
4,6-Dinitro-0-sec. butylphenol (DNBP), 3 lb/gal								
pre-emergence	3		9.8		8.6		0.0	----
1961*	6		10.0		9.6		1.3	----
1963	4-1/2	4.5	0.8	3.8	1.0	0.2	0.1	4291
N,N-dimethyl-, -diphenylacetamide (diphenamid), 80W								
pre-emergence	3	7.8	6.9	9.6	7.9	0.4	1.2	----
1962	4-1/2	6.4	6.1	10.0	10.0	0.3	0.7	----
	6	9.3	8.6	10.0	10.0	0.0	0.6	----
1963	4	0.8	0.7	2.1	0.7	0.2	0.5	3660
	6	0.6	0.0	2.6	2.7	0.0	1.0	2419
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), 4 lb/gal								
pre-emergence	1 inc.	4.7	2.2	5.9	1.9	1.1	2.1	----
	2 inc.	6.3	4.4	8.5	3.8	1.1	0.8	----
1962	2	4.6	2.4	6.7	1.6	0.3	0.6	----
	4	6.2	2.8	7.3	1.9	0.1	0.3	----
	6	7.0	2.3	8.7	5.4	0.1	0.8	----
1963	4	8.6	3.3	9.0	6.0	0.1	0.5	3428
	6	9.8	7.3	9.6	9.5	0.1	0.1	6667
pre-plant	1/2 inc.	8.2	1.0	7.8	2.0	0.3	0.3	3666
1963	1 inc.	8.8	1.8	8.8	2.3	0.3	0.7	4574
	2 inc.	9.3	3.3	9.3	3.0	2.5	2.0	4174
Dimethyl 2,3,5,6-tetrachloroteraphthalate (DCPA), 75W								
pre-emergence	6	8.5	6.9	8.2	1.6	0.4	0.0	----
1962	8	9.2	7.2	8.0	3.0	0.0	0.4	----
1963	8	3.1	0.7	4.4	1.8	0.5	0.3	3492
	12	5.9	2.9	6.3	4.3	0.1	0.6	4711
Methyl N-(3,4-dichlorophenyl) carbamate (sweep), 2 lb/gal								
pre-emergence	3	9.4	8.4	6.1	2.3	0.2	0.4	----
1962	6	10.0	10.0	9.2	6.3	1.2	2.8	----
1963	3	3.8	1.7	4.3	1.1	0.0	0.3	4249
	6	5.9	3.3	5.0	3.8	0.2	0.2	3891
80W	3	3.4	4.4	3.6	1.1	0.6	0.4	5174

Table 2. (continued)

Treatment	Rate, lb/A	Weed Control				Crop Injury		Crop Yields lb/A
		Broadleaves		Grasses		Stand ¹	Vigor ²	
		Stand ¹	Vigor ²	Stand ¹	Vigor ²			
Sodium N-1-naphthyl pthalamate (NPA), 2 lb/gal pre-emergence								
1962	4	7.9	7.3	7.4	6.0	1.7	2.8	----
1963	3	2.7	0.0	1.2	0.4	0.0	0.3	2334
Uncultivated Check								
1962		2.7	1.6	0.0	0.0	0.5	2.6	----
1963		0.0	0.0	0.0	0.0	0.0	0.0	1851
Cultivated Check								
1963		5.8	0.9	6.2	3.1	0.0	0.0	3681

¹Based on scale 0 to 10; 0 = no effect, 10 = reduced 100%.

²Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

*Ratings in 1961 were general rather than broken down into stand and vigor ratings.

Results and Discussion

In Tables 1 and 2 are found summaries of weed control, crop injury data, and the yields of snap and lima beans, respectively.

For ease of presentation the two crops will be discussed separately.

Snap Beans

Trifluralin was the outstanding herbicide. Good weed control was achieved by both pre-emergence and pre-plant applications. Pre-plant applications effected excellent weed control, but yields were greater with pre-emergence applications.

Pre-plant applications of EPTC and R-1607 gave excellent weed control; however, EPTC caused greater crop injury and lower yields than R-1607.

The benefits gained from pre-plant applications were demonstrated with R-1910 and R-4572. Poor weed control was obtained with both herbicides applied pre-emergence, but weed control efficiency was greatly increased with pre-plant applications, very

DNBP, DCPA, and swep gave fair weed control, but yields were generally good.

Amiben, NPA, and especially diphenamid were not too effective; however, the yields were not poor. The unusually dry season contributed much to their poor performance

Lima Beans

Weed control with EPTC in lima beans was less than that observed in snap beans. The yields, however, with EPTC treatments were among the highest.

The 1961 and 1963 experiments with R-1607 both revealed very good weed control with little difference between pre-emergence or pre-plant applications. Pre-emergence treatments caused more crop injury than the pre-plant ones.

Results with R-1910 and R-4572 on lima beans were similar to those on snap beans. Pre-plant applications were considerably better than pre-emergence applications. Only the six-pound pre-plant rate of R-4572 effected some crop injury and a slight decrease in yield.

Weed control with amiben, DNBP, DCPA, NPA, swep and diphenamid was greater in 1961 and 1962 than in 1963. DCPA and swep were the best of the six herbicides, producing more weed control and higher yields in 1963. Diphenamid and NPA were ineffective herbicides; the dry season having much to do with their failure.

Contrary to the performance of the previously mentioned herbicide, trifluralin performed better in 1963 than in 1962. Soil incorporation of this herbicide gave better weed control, in pre-emergence applications in 1962 and pre-plant applications in 1963, than unincorporated applications. However, soil incorporation caused more crop injury and yield reductions.

Summary

The effects of a number of herbicidal treatments on snap and lima beans were evaluated. Observations were made and data were taken on weed control, crop injury, and yield.

Pre-plant applications gave better weed control in both snap and lima beans than did pre-emergence applications.

The extremely dry growing season of 1963 was responsible for such herbicides as amiben, diphenamid, DCPA, DNBP, NPA and swep to be much less effective than they were in 1961 and 1962.

Trifluralin was the best herbicide on both crops; the dry growing season not affecting its efficiency. Soil incorporation of high rates of trifluralin caused crop injury on lima beans.

EVALUATION OF SEVERAL HERBICIDES FOR BARNYARD GRASS
CONTROL IN LIMA BEANS AND SNAP BEANS

C. T. Dickerson and E. M. Rahn¹

Barnyard grass, Echinochloa crusgalli, is a serious problem on several thousand acres of lima and snap beans grown for processing in Delaware. Not only does this grass compete vigorously with crops, but also it interferes with mechanical harvesting, causing breakage of machinery. The main objective of the tests reported below was to evaluate some of the newer herbicides for barnyard grass control in snap and lima beans, using a logarithmic sprayer.

PROCEDURE

Thaxter lima beans and Harvester snap beans were planted on June 13, 1963, at the University of Delaware Farm in Newark, Delaware, on Matapeake loam soil. The soil at the time of planting contained approximately 75% available moisture. Beans were planted at a depth of 1-1/2 inches and, to insure uniform infestation, barnyard grass was planted just above the beans at a depth of 1/2 inch. Each plot consisted of one row of lima beans and one row of snap beans, three feet apart, and 75 feet long. Treatments were replicated twice in a randomized block design. Herbicides, rates, and time of application appear in Table 1. A logarithmic sprayer was used to apply the herbicides, using 100 gallons of water per acre as a carrier. Pre-plant herbicide applications were made just before planting and were soil-incorporated immediately to a 4-inch depth with a rototiller. Pre-emergence herbicides were applied just after seeding. Post-emergence treatments were applied June 24 when lima beans and snap beans were about 3 inches tall and primary leaves were not fully expanded; and barnyard grass was 3/4 of an inch tall.

Ratings of barnyard grass control and crop injury were recorded July 1, July 31, and on the day each crop should have been harvested, which was August 15 for snap beans and September 4 for lima beans (Table 1).

Plots were not irrigated. Rainfall for the first, second, third, and fourth weeks after seeding was extremely low: .09 in., .30 in., .25 in., and .01 in., respectively. This was approximately 3 inches below the normal rainfall for this period.

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RESULTS AND DISCUSSION

The only chemicals that gave acceptable barnyard grass control were those that were applied as pre-planting treatments and soil-incorporated. Poor performance of some of the other chemicals that were not incorporated probably was due to lack of rainfall to "activate" them.

Trifluralin was the only herbicide that gave good barnyard grass control in lima beans without crop injury. Lima beans tolerated 2.2 lb/A without crop injury, and complete barnyard grass control was achieved at the lowest rate of application: 1.5 lb/A. Snap beans were more tolerant to trifluralin than lima beans, tolerating 3.3 lb/A. Barnyard grass control was again achieved at the lowest rate of application: 1.5 lb/A. EPTC, Stauffer R-1607, and Stauffer R-4572 also gave excellent barnyard grass control with a much wider margin of safety on snap beans. Barnyard grass was controlled with as little as 2.0 lb/A of EPTC, 3.3 lb/A of R-1607, and 4.5 lb/A of R-4572. No injury was observed at the highest rate of application 9.4 lb/A with EPTC, R-1607, and R-4572.

EPTC has given excellent barnyard grass control in growers' fields when applied as a band application. During the summers of 1962 and 1963, one Delaware grower treated a total of 600 acres with EPTC at 2 lb/A applied as a 12 inch band over the freshly planted snap bean row. The EPTC was soil-incorporated by passing a spike-tooth harrow over the treated area twice. The harrow was set to incorporate to a depth of 1-1/2 inches, thus not disturbing the planted seed. This practice has been very satisfactory since it cut herbicide costs and gave excellent barnyard grass control in the 12 inch band where it was applied.

CONCLUSIONS

Under low rainfall conditions, trifluralin was the only effective herbicide for control of barnyard grass without crop injury to lima beans. No crop injury was observed below 2.2 lb/A and control was obtained at the lowest rate of application: 1.5 lb/A.

For snap beans grown under low rainfall, three herbicides were effective for barnyard grass control. Trifluralin controlled grass at the lowest rate applied, 1.5 lb/A; EPTC controlled grass as low as 2.0 lb/A, and R-1607 as low as 3.3 lb/A. Trifluralin injured snap beans above 3.3 lb/A; EPTC and R-1607 did not injure beans at the highest rate of application, 9.4 lb/A.

TABLE 1.

MAXIMUM RATE OF HERBICIDE TOLERATED BY
LIMA BEANS AND SNAP BEANS AND MINIMUM
RATE NEEDED FOR BARNYARD GRASS CONTROL

Herbicide & Rate in lb/A	Time of Application	Max. Rate Tolerated By		Min. Rate Required For Grass Control	
		Snap lb/A	Limas lb/A	Snap lb/A	Limas lb/A
EPTC 1.5 to 9.4	Pre-Plt.Inc.	>9.4	1.8	2.0	1.8
Stauffer R-1607 1.5 to 9.4	Pre-Plt.Inc.	>9.4	1.7	3.3	3.3
Stauffer R-4572 1.5 to 9.4	Pre-Plt.Inc.	>9.4	4.3	4.5	3.4
Trifluralin 1.5 to 9.4	Pre-Plt.Inc.	3.3	2.2	<1.5	<1.5
Amer.Cyanamid AC201 1.5 to 9.4	Pre-Emerg.	<1.5	2.2	>9.4	>9.4
DCPA 3 to 18.8	Pre-Emerg.	5.4	>18.8	>18.8	15.0
Diphenamid 1.5 to 9.4	Pre-Emerg.	2.1	>9.4	8.0	5.4
Hercules 7531 1.5 to 9.4	Pre-Emerg.	<1.5	1.7	6.3	5.5
Linuron .3 to 1.9	Pre-Emerg.	1.7	>1.9	1.6	1.6
Sweep 1.5 to 9.4	Pre-Emerg.	9.4	7.9	>9.4	>9.4
Union Carbide U22463 1.5 to 9.4	Pre-Emerg.	5.0	3.3	6.8	5.6
Pitts.Plate Glass BP-2 1.5 to 9.4	Post-Emerg. ¹	3.8	5.8	>9.4	>9.4
Pitts.Plate Glass BP-7 1.5 to 9.4	Post-Emerg. ¹	2.7	3.2	>9.4	>9.4
DPA 1.5 to 9.4	Post-Emerg. ¹	<1.5	2.4	4.5	4.5

1. Applied 11 days after seeding when beans and barnyard grass were 3 in. and 3/4 in. high, respectively.

Chemical Weeding of Beets

Charles J. Noll

Experimental attempts to weed beets with herbicides have been interesting but usually not very rewarding. Even the best of the recommended chemicals, a combination of endothall and TCA, requires exact application timing under good weather conditions for weed germination to get good weed kill. Solubor has been reported as being used successfully to weed beets on a commercial scale but our results with this herbicide have been poor as compared to the endothall, TCA combination.

A new chemical PCA (1-phenyl-4-amino-5-chloropyridazone-6) was reported as promising for weeding of beets. Much of the work reported in this paper deals with the weeding of beets with this herbicide.

Procedure

The seedbed was prepared April 26. On May 2 preplanting treatments were applied and incorporated with a rototiller set shallow. The plots were seeded to the variety Detroit Dark Red the same day. Other herbicides were applied from 1 day after seeding to 13 days after seeding. Individual plots were 28 feet long and 2 feet wide. Treatments were randomized in each of 8 blocks.

All chemicals were applied with a small sprayer. The soil incorporated chemicals were sprayed over the row for a width of 2 feet. The boron treatments had the full acre rate applied in a six inch band over the row and all other treatments were in a 1 foot band over the row. Beets were slow to emerge due to the dry weather but were through the ground by the 10 days after seeding. Cultivation controlled the weeds between the rows. An estimate of weed control was made June 20 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. The growing season was very dry, irrigation was applied. Harvest records were made July 22.

Results

The results are presented in Table 1. All chemicals significantly increased weed control as compared to the untreated plots. Taking into consideration weed control, plant stand and yield only two treatments warrant further discussion. These are the endothall and TCA combination and PCA. The endothall, TCA combination applied just prior to beet emergence is the recommended practice in Pennsylvania. Although both a 50% and an 80% PCA herbicide were in the trials no consistent differences were found between the two.

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The PCA incorporated treatments were applied the day of planting at rates of 6 and 9 lbs. per acre. The pre- and post-emergence treatments were applied 1 day, 4 days, 7 days, 10 days and 13 days after planting at the rate of 4 lbs. per acre. Weed control with the incorporated treatments was good but stand and yield were poorer than all the pre-emergence treatments using the same chemical. With the pre- and post-emergence treatments of PCA weed control increased and stand decreased as applications were delayed. The best yield of beets as measured by beet weight was in plots treated 7 days after seeding, prior to beet emergence.

Conclusion

The chemical PCA is promising for the weeding of beets. The delayed pre-emergence application gave the best results.

Table 1. Weed Control, Stand of Plants and Weight of Roots of Beets under Chemical Herbicide Treatments

Treatment	Active Rate per Acre lbs.	Application Days from Planting	AVERAGE PER PLOT		
			*Weed Control (1-10)	Stand of Plants	Wt. of Beets lbs
1. Nothing	--	--	7.4	78.3	1.6
2. PEBC (Tillam)	4 (2' wide)	Inc. - 0	2.5	56.0	3.8
3. " "	6 " "	" - 0	2.3	32.1	2.4
4. PCA (ACP 62-215 A)	6 " "	" - 0	2.9	53.9	3.9
5. " "	9 " "	" - 0	1.8	53.4	3.5
6. CDEC	6	Pre + 5	4.5	88.9	4.3
7. " "	9	" + 5	5.3	67.4	4.1
8. Boron (Solubor)	5 (6" band)	" + 1	4.6	95.6	3.4
9. " "	7 1/2 "	" + 1	5.0	116.9	3.1
10. Trifluralin	2 "	" + 1	3.1	1.8	.1
11. " "	3	" + 1	1.8	.0	.0
12. Alipur 0	4	" + 1	1.1	29.0	.9
13. " "	6	" + 1	.0	4.3	.1
14. " OC	4	" + 1	1.3	.4	.0
15. " "	6	" + 1	1.3	2.4	.0
16. Endothal + TCA	6 + 10	" + 7	4.0	119.0	4.2
17. PCA (HS-119-1)	4 lb.	" + 1	4.3	112.0	4.8
18. " (HS-119)	"	" + 1	4.4	109.3	5.0
19. " (HS-119-1)	"	" + 4	3.1	110.1	6.4
20. " (HS-119)	"	" + 4	3.1	117.4	6.1
21. " (HS-119-1)	"	" + 7	3.5	107.9	6.9
22. " (HS-119)	"	" + 7	2.6	92.1	9.8
23. " (HS-119-1)	"	" +10	2.8	96.6	5.6
24. " (HS-119)	"	" +10	2.9	73.3	4.6
25. " (HS-119-1)	"	Post +13	2.4	75.4	4.1
26. H (HS-119)	"	" +13	2.1	72.1	5.1
Least significant difference 5%			1.8	36.9	2.4
1%			2.4	48.7	3.1

*Weed Control 1-10: 1 Perfect Weed Control; 10 Full Weed Growth.

CHEMICAL WEED CONTROL IN CUCURBITS

H. M. LeBaron

The production and value of cucurbits in Virginia have been increasing fairly sharply during recent years. This is particularly true with cucumbers and watermelons, each of which is planted on 5,000 to 8,000 acres per year, returning an average combined farm income of about 2 million dollars. There is only minor commercial production of cantaloupe, squash, and pumpkin in Virginia.

As is the case with most other vegetable crops in the state, practically all of the cucurbit production is in the eastern coastal plain areas. Cucumbers are grown for both fresh market and pickling. Fresh market cucumbers are planted as two separate crops; i.e., early summer and early fall, with most of the increased acreage in the early fall category.

While weeds are not normally considered one of the major hazards in commercial production of cucurbits in eastern Virginia, the interest in a safe and effective herbicide to supplement cultivation and tillage practices is increasing. Because of the different times of the year when cucurbits are grown, a variety of weed problems may develop. While nutgrass infestations, particularly in watermelons, probably represent the most difficult cucurbit weed problem to solve at the present time, various annual grasses and broadleaf weeds may also cause serious difficulties and labor expense. This is especially true in wet seasons when timely cultivations are impossible and after vining or lay-by.

Our standard recommendation for the control of annual weeds in most cucurbits has been NPA (Alanap-3) at the rate of 3 to 4 lbs/A applied at planting time. It may also be used after the crop is up following a cultivation. While NPA is quite safe on most cucurbits it has not always resulted in satisfactory control of weeds. NPA seldom gives control for longer than 3 to 4 weeks and may completely fail on our sandy loam soils: (1) if there is not surface moisture either at or shortly after application, (2) when there is excessive rainfall, or (3) when weeds have emerged prior to application.

MATERIALS AND METHODS

In an effort to evaluate the safety and effectiveness of the newer herbicides and improve the weed control recommendations for cucurbits, preliminary tests were conducted on cucumbers during 1961 and 1962. From this work and from results reported elsewhere, several promising herbicides and experimental chemicals were found. These were all included in an experiment this season in which the crop sensitivities of various cucurbits were evaluated.

The experiment consisted of two varieties of cucumbers (Ashley and Ohio 17 Pickler), two varieties of muskmelons (Hale Jumbo and Honeydew), two varieties of watermelon (Charleston Grey and Sugar Baby), two varieties of squash (Early Prolific Straightneck and Butternut), and one variety of pumpkin (Jack O'Lantern).

The seedbed was prepared on May 27, 1963. All preplant incorporation treatments were applied on May 27 and worked in within minutes to a depth

of about two inches by a double harrowing with a spiketooth harrow. All crops were planted to a depth of about 1 inch on May 28, and all preemergence treatments were made the same day. Soil moisture was good but the soil surface was loose and dry.

The conditions under which this experiment was conducted provided a very severe test of crop sensitivity to the herbicides, as well as the weed control effectiveness of the herbicides under extreme leaching. Although the 1963 season was extremely dry, generally, most of the precipitation fell within a week after this experiment was set out. The recorded rainfall at the Painter (Eastern Shore Branch) Station, where this study was conducted, was: May 29, 0.30 in.; May 30, 0.44 in.; June 2, 1.97 ins.; and June 3, 2.43 ins., giving a total of 5.14 inches in less than one week. The soil is classified as a Sassafras fine sandy loam.

RESULTS AND DISCUSSION

The chemical treatments and a summary of the results are presented in Tables 1 and 2. The average cucurbit rating represents the average stand of all crops from three replications. The rating system was based on a scale in which 0 = no stand, and 10 = complete or uniform stand. A rating of 7 would be considered commercially acceptable and would not be expected to affect yield significantly. The control ratings on annual grass and broadleaf weeds are based on a scale in which 0 = complete infestation (virtually no soil visible) and 10 = no weeds present. Again a rating of 7 would be considered commercially acceptable or satisfactory control. Annual grasses consisted mostly of crabgrass, goosegrass, and love grass. The predominant broadleaf weed was carpetweed, with some present in all plots. Other broadleaf weeds which were generally present where they were not controlled by herbicide include pigweed, lambsquarter, smartweed, swinecress, and knotweed. While the complete Duncan multiple range test is given in Table 1 for significant differences at the 5% level in weed control ratings, only partial multiple range tests are presented in Table 2 for crop stand reduction ratings, since the lower values are of little or no practical importance.

The results demonstrate quite conclusively that none of the preplant incorporation treatments can safely be used on cucurbits in eastern Virginia. This has been supported by other tests both this year and in the past. However, it does show that of the preplant herbicides used, cucurbits have by far the greatest natural tolerance to Betasan. This is also indicated from the results when these herbicides were applied preemergence after planting, with no incorporation. Even when applied to the soil surface in this manner, relatively few herbicides are sufficiently safe when followed by heavy precipitation in light soils to warrant further investigation for use in cucurbits.

The best treatment in this experiment from the standpoint of crop tolerance and weed control was Dacthal at 8 lbs/A. While some weeds survived, control of both grasses and broadleaves was rated commercially acceptable. At the rate of 4 lbs/A, which has usually given good control of grasses and some broadleaves, weed control was not satisfactory in this test. Other materials which gave very good control of annual grasses without significant

Table 1 Herbicides and Weed Control Effectiveness in Cucurbits,
Eastern Shore, 1963

Number	Herbicide	Treatment	Grass					Broadleaf							
			Rating												
1	Triflu.	1 Pre.Pl.Inc.	5.67		c	d	e	5.00	a	b	c	d			
2	Triflu.	2 Pre.Pl.Inc.	6.67	b	c	d	e	7.67	a	b					
3	Tillam	3 Pre.Pl.Inc.	7.00	a	b	c	d	e	4.33	b	c	d	e		
4	Tillam	6 Pre.Pl.Inc.	7.00	a	b	c	d	e	6.67	a	b	c			
5	R1870	4 Pre.Pl.Inc.	7.67	a	b	c	d	e	2.33			d	e	f	
6	R1870	8 Pre.Pl.Inc.	9.00	a	b				4.33	b	c	d	e		
7	Betasan	5 Pre.Pl.Inc.	6.67	b	c	d	e		.33				f		
8	Betasan	10 Pre.Pl.Inc.	7.67	a	b	c	d	e	.67				f		
9	R4572	4 Pre.Pl.Inc.	6.67	b	c	d	e		4.33	b	c	d	e		
10	R4572	8 Pre.Pl.Inc.	6.00	b	c	d	e		5.67	a	b	c	d		
11	Triflu.	1 Preemg.	8.00	a	b	c	d		6.33	a	b	c			
12	Triflu.	2 Preemg.	8.00	a	b	c	d		8.00	a					
13	Tillam	3 Preemg.	5.67			c	d	e	4.67	a	b	c	d	e	
14	Tillam	6 Preemg.	8.33	a	b	c	d		6.67	a	b	c			
15	R1870	4 Preemg.	7.33	a	b	c	d	e	1.67				e	f	
16	R1870	8 Preemg.	9.00	a	b				2.33			d	e	f	
17	Betasan	5 Preemg.	8.00	a	b	c	d		1.00				f		
18	Betasan	10 Preemg.	9.00	a	b				1.00				f		
19	R4572	4 Preemg.	8.00	a	b	c	d		6.00	a	b	c			
20	R4572	8 Preemg.	10.00	a					8.00	a					
21	DNBP	3 Preemg.	2.33					g	4.33	b	c	d	e		
22	DNBP	6 Preemg.	6.00	b	c	d	e		5.33	a	b	c	d		
23	Diphen.	1 Preemg.	5.33			d	e	f	5.67	a	b	c	d		
24	Diphen.	2 Preemg.	7.67	a	b	c	d	e	6.67	a	b	c			
25	Dacthal	4 Preemg.	5.33			d	e	f	6.00	a	b	c			
26	Dacthal	8 Preemg.	7.33	a	b	c	d	e	7.67	a	b				
27	Dacthal	24 Preemg.	8.00	a	b	c	d		7.33	a	b				
28	Amiben	4 Preemg.	5.33			d	e	f	3.33	c	d	e	f		
29	Amiben	8 Preemg.	7.33	a	b	c	d	e	4.67	a	b	c	d	e	
30	Amiben	16 Preemg.	8.67	a	b	c			7.00	a	b				
31	NPA	6 Preemg.	5.33			d	e	f	3.33	c	d	e	f		
32	CDEC	4 Preemg.	4.67			e	f	g	4.67	a	b	c	d	e	
33	Check		2.67					f	g	2.33			d	e	f

Table 2 Effect of Herbicides on the Stand of Cucurbit Crops,
Eastern Shore, 1963

Number	Cucumber Rating	Cantaloupe Rating	Watermelon Rating	Squash Rating
1	3.67	3.67	2.00	2.67
2	.67	1.33	2.33	.67
3	.67	1.67	.33	1.00
4	.33	.33	.33	.67
5	2.67	3.33	5.33	2.67
6	3.00	3.33	3.67	.67
7	4.67 c d	7.00 a b c d	8.67 a b c d	6.00 a b c d
8	6.00 a b c d	6.00 b c d	4.67	4.00 c d
9	.67	1.33	1.33	.33
10	.67	1.00	.00	.33
11	3.67	4.00	6.67 b c d	4.67 b c d
12	3.00	4.67 c d	7.67 a b c d	4.67 b c d
13	4.00 d	5.33 b c d	6.67 b c d	4.00 c d
14	.67	3.33	5.00	2.00
15	8.00 a b c	6.67 a b c d	8.33 a b c d	8.00 a b
16	6.00 a b c d	6.00 b c d	8.67 a b c d	7.67 a b
17	9.00 a	7.00 a b c d	10.00 a	6.00 a b c d
18	9.00 a	7.00 a b c d	9.33 a b	6.00 a b c d
19	4.67 c d	5.67 b c d	6.00 d	4.67 b c d
20	1.00	2.00	.33	1.00
21	8.00 a b c	8.00 a b	9.00 a b c	8.67 a
22	6.67 a b c d	6.67 a b c d	9.00 a b c	7.33 a b c
23	5.00 c d	6.67 a b c d	9.33 a b	7.33 a b c
24	2.67	3.67	6.33 c d	3.33 d
25	7.00 a b c d	8.00 a b	9.00 a b c	8.00 a b
26	7.33 a b c d	7.67 a b	9.33 a b	8.33 a
27	5.33 b c d	6.67 a b c d	8.33 a b c d	8.00 a b
28	5.33 b c d	9.00 a	9.00 a b c	6.67 a b c d
29	4.00 d	9.33 a	6.67 b c d	6.00 a b c d
30	1.33	4.33 d	2.00	5.67 a b c d
31	5.00 c d	7.67 a b	8.00 a b c d	3.33 d
32	5.00 c d	7.33 a b c	8.67 a b c d	6.00 a b c d
33	8.67 a b	8.00 a b	8.67 a b c d	8.33 a

stand reductions were R1870 at 4 or 8 lbs/A, and Betasan at 5 or 10 lbs/A. However, these chemicals have no effect on broadleaf weeds.

Herbicides which did not appreciably affect cucurbit stand under the severe rainfall conditions of this experiment and are therefore worthy of further work and consideration, even though weed control was not rated as commercially acceptable, include: DNBP at 3 or 6 lbs/A, Amiben at 4 or 8 lbs/A, NPA (on all cucurbits except squash and pumpkin) at 6 lbs/A, and CDEC at 4 lbs/A.

No varietal differences in herbicidal tolerance were noted within any of the cucurbit crops. It was also a general rule that there was a similar, though not always equal, response between crops to a particular herbicide. Exceptions can be noted as in the case of NPA, which show squash and cucumber stands to be significantly lower than in untreated plots, while no such decrease occurred with cantaloupe and watermelon. It is also apparent that cucumbers have less tolerance for Amiben than the other crops, showing injury even from the low rate. Effects of Dacthal at the high rate indicate that cucumbers are most susceptible to injury, with cantaloupes next. CDEC also shows a significant differential crop response, with no reduction in stand except on cucumbers.

Summary and Conclusions

1. Severe injury to all cucurbit crops resulted from the preplant incorporation treatments, with the exception of Betasan which showed no or slight stand reductions at the low rate.
2. Stand reductions ranging from slight to virtually complete kill also occurred from many of the preemergence treatments.
3. The most promising preemergence treatments based on crop tolerance and weed control were Dacthal at 8 lbs/A, Betasan at 5 and 10 lbs/A, and R1870 at 4 and 8 lbs/A. Dacthal was the only one of these herbicides to control broadleaf weeds effectively as well as grasses.
4. Other preemergence herbicides which showed promising crop tolerance but poor weed control in this experiment were DNBP, Amiben, NPA, and CDEC.
5. Most of the promising herbicides demonstrated a degree of differential crop selectivity at some rates.
6. Cucumbers were most sensitive to stand reductions from most herbicides.
7. A major factor influencing the results of this experiment was believed to be the heavy precipitation during the first week after treatments.

Chemical Weeding of Onions Grown from Sets

Charles J. Noll

Onions in Pennsylvania are grown from seeds, sets and from transplants. Little has been reported on weeding onions grown from sets as the total acreage is relatively small although many of our institutions grow a sizeable portion of their onions from sets. This report summarizes the results of chemical weeding of set onions grown on the Horticultural Farm near University Park.

Procedure

The seedbed was prepared and planted April 16. All chemicals were applied from 1 to 35 days after the sets were planted. Some of the plots were sprayed with both pre-emergence and post-emergence herbicides. Individual plots were 28 feet long and 2 feet wide. Six tenths of a pound of sets of the variety Yellow Ebenezer were planted in each plot. Treatments were randomized in each of 8 blocks.

The chemicals were applied with a small sprayer over the row for a width of 2 feet. Cultivation controlled the weeds between the rows. An estimate of weed control was made June 20 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. The growing season was very dry and irrigation water was applied. Onions were harvested September 24.

Results

The results are presented in Table 1. All chemicals resulted in a significant increase in weed control as compared to the untreated check. The best weed control with one application of herbicide was in the plots treated with dichlobenil and TD 480. In plots treated twice the best weed control was found in the plots treated with CIPC, DCPA and SI 6623.

Stand was reduced as compared to the untreated plot by the herbaceous diquat and paraquat. No plot had a significantly better stand than the check. Yields significantly better than the untreated check, from best to poorest, were: DCPD at 16 and 24 lbs. per acre applied twice, CIPC at 8 and 12 lbs. per acre applied twice, SD 6623 at 8 lbs. per acre applied twice, KOCN at 12 and 18 lbs. per acre in 100 gals. water applied twice, dichlorobenit at 4 lbs. per acre applied once and CMAA at 6 lbs. per acre applied once.

Conclusion

Under the conditions of this experiment a number of chemicals look

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promising for the weeding of onions grown from sets. Probably the most promising is DCPA as it gave good weed control, good stand and good yields. The onions were tolerant of this chemical when applied prior to emergence as well as after emergence at relatively high rates. Other chemicals of interest taking into consideration weed control, stand and yield are CIPC, SD 6623 and dichlorobenil.

Table 1. Weed Control, Stand of Plants and Weight of Bulbs of Onions Grown from Sets under Chemical Herbicide Treatment

Treatment	Active Rate per Acre lbs.	Application Days from Planting		AVERAGE PER PLOT		
		1st	2nd	*Weed Control (1-10)	Stand of Plants	Weight of Bulbs lbs.
1 Nothing	--	--	--	9.3	123.0	21.0
2 Dichlobenil	4	+23	--	1.9	121.1	28.6
3 DCPA	16	+ 1	+34	1.9	122.1	32.3
4 "	24	+ 1	+34	2.1	127.0	35.5
5 CIPC	8	+ 1	+34	1.6	124.0	31.0
6 "	12	+ 1	+34	1.8	121.1	30.7
7 TD 480	6	+ 1	--	2.6	114.8	25.4
8 TE 482	6	+ 1	--	5.0	121.9	23.2
9 SD 6623	8	+ 1	+34	2.4	132.6	30.8
10 Diquat	1	+ 6	+34	4.9	82.3	13.1
11 Paraquat	1	+ 6	+34	4.6	27.4	3.5
12 CDA	6	+ 6	--	4.6	125.3	25.9
13 "	9	+ 6	--	4.4	122.0	24.0
14 KOON	12 (100 gal.)	+ 6	+35	3.3	128.2	29.9
15 "	18	+ 6	+35	3.0	119.5	29.2
16 Swep	4	+16	--	2.5	124.0	27.0
Least significant difference	5%			1.4	16.3	4.6
	1%			1.8	21.5	6.1

*Weed control 1-10: 1 Perfect Weed Control
10 Full Weed Growth

J. D. Riggleman and Dorothy Ann White^{2/}

Preliminary evaluations for determining safe and effective rates have become a necessity with the increasing number and wider range of selectivity of today's herbicides. The exponential sprayer (1) and gradient distributor for granular materials (2) have made possible the rapid and efficient evaluation of herbicides in multi-crop tests.

Method of application governs the behavior of most herbicides. Comparisons were made among incorporation, surface applications, vapor seals or semi-incorporation with irrigation and granular applications.

Materials and Methods

The studies were conducted at the University of Maryland Vegetable Research Farm, Salisbury. The soil is a well drained loamy sand. The season was unusually dry. No supplemental irrigation was applied except that used for the vapor seals. KC 146 tomato transplants and Nemagold sweet potato sprouts were planted May 6 in 64 inch beds 110 feet long and then inter-seeded with Gallatin 50 or Tendercrop snap beans, Pocomoke tomatoes, Harvest Queen cantaloupes, crabgrass, pigweed and German fox-tail millet. The first 10 feet of the plot were untreated. Following the untreated area the exponential sprayer was used starting at 16 lbs AI/A (unless otherwise indicated) and exponentially decreasing for 4 half-dosages to 1/16 of the initial rate. The starting rate with the gradient distributor varied, due to the differences in concentration, density and fineness of the granular materials. Herbicides were applied pre-planting with soil incorporation; within 24 hours after planting; within 24 hours after planting followed by $\frac{1}{2}$ inch of irrigation; within 24 hours after planting as a granular material; and 4 weeks after planting. Plots were evaluated 2 or 3 times. The plots were disced in mid-July and then seeded to oats on July 22. Injury to the oats was recorded August 16. The field was plowed September 2 and drilled to rye September 10. The injury to rye was recorded October 31.

Results and Discussion

The data are presented in Table 1. Of the recently introduced herbicides, several appear promising for weed control in horticultural crops for periods of 8 weeks or more.

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Snap beans. CP 17029 at 3 lbs AI/A caused no injury to snap beans while 2 lbs AI/A were necessary for weed control. SD 6623 at 16 lbs AI/A caused no injury to the beans; 16 lbs AI/A were also necessary for adequate weed control. Post emergence applications 4 weeks after planting of Paraquat at 4 lbs AI/A caused no injury to the beans. Only $\frac{1}{2}$ lb AI/A was necessary for control.

Transplanted tomatoes. Post emergence applications of Linuron at 2 to 4 lbs AI/A 4 weeks after planting caused no apparent injury to tomatoes. Similar rates were necessary for effective weed control.

Direct seeded tomatoes. Tomatoes were tolerant of 16 lbs AI/A of SD 6623, which was the same rate needed for effective weed control.

Sweet potatoes. Linuron at 2 to 4 lbs AI/A caused no injury to sweet potatoes. For effective weed control 2 to 4 lbs AI/A were necessary. Sweet potatoes tolerated 10 lbs AI/A of CP 31675 and 5 lbs AI/A of CP 17029. Effective control was obtained from 10 and 2 lbs AI/A respectively. No injury was obtained from 6 lbs AI/A of HP 7531 or 16 lbs AI/A of Alipur. Effective control was obtained from 6 and 5 lbs AI/A respectively. When applied 4 weeks after planting, Paraquat at 6 lbs AI/A caused no injury; only $\frac{1}{2}$ lb AI/A was necessary for control.

Cantaloupes. Cantaloupes showed no injury symptoms from 16 lbs AI/A of SD 6623 while 16 lbs AI/A were also necessary for weed control. The granular formulation of Trifluralin caused no injury to the cantaloupes at 11 lbs AI/A; 9 lbs AI/A were necessary for control.

Oats. Subsequent to discing down the crop plants, oats were planted. This was 11 weeks after herbicides were applied to the original "pre-plant incorporated" and "at-planting" plots. Several herbicides caused residual injury to oats at rates needed earlier for adequate weed control. Dichlobenil, SD 7961 or Trifluralin incorporated at 1 lb AI/A injured oats. When sprayed on the surface, SD 6623 injured oats at 8 lbs AI/A. The granular formulation of DNEP injured oats at 3 lbs AI/A.

Only 7 weeks elapsed between the "delayed (4 weeks after planting) application" and oat seeding. Injury was observed from applications of 2 lbs AI/A of Diphenamid or Linuron.

Rye. A cover crop of rye was seeded 4 months after the initial herbicide treatments and 3 months after the delayed treatments. At rates necessary for adequate weed control, the incorporation of 1 lb AI/A of Dichlobenil or SD 7961 injured the rye.

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- (1) Dedolph, R. R., C. W. Basham and F. C. Stark. 1960. An exponential sprayer for experimental work. Proc. Amer. Soc. Hort. Sci. 75:785-88.
 - (2) Riggleman, J. D., G. J. Burkhardt and F. C. Stark. 1963. A gradient distributor for the application of granular materials. Proc. Northeastern Weed Control Conference, Jan. 1963.

Table 1. Effects of herbicides applied with an exponential sprayer and gradient distributor to several horticultural crops^{1/}, cover crops^{2/} and weed species^{3/}.

Treatments ^{4/}	Obsv Date	Beans ^{5/}		T. Tom		S. Tom		S. Pot		Canta		Millet ^{7/8/}		Crab		Pigw		Native		Oats	R
		A ^{3/}	B ^{6/}	A	B	A	B	A	B	A	B	C ^{7/}	D ^{8/}	C	D	C	D	G	B1	8/16	
AC 201 AP	2S	6/4	16 S	16 S	4 S	16 5	4 S	NC	16	-	-	-	-	4	4	14	1				
		6/25	16 S	6 S	6 2	14 2	S S	6	6	-	-	-	-	6	6						
		7/12	3 S	6 S	6 6	14 6	S S	6	2	-	-	-	-	6	6						
4 wks	2S	6/25	16 2	16 S	16 S	16 4	16 S	NC	NC	NC	NC	NC	NC	NC	NC	10	1				
		7/10	16 2	16 S	16 S	16 S	16 S	16 S	NC	NC	NC	NC	NC	NC	NC	NC					
Alanap AP	2S	6/4	10 4	16 S	16 S	13 4	16 16	NC	NC	-	-	-	-	1	1	16	1				
		6/25	16 2	16 S	16 3	16 S	16 16	NC	NC	-	-	-	-	16	16						
		7/12	16 S	16 S	16 16	11 11	16 16	NC	NC	-	-	-	-	16	16						
Alipur AP	2E	6/4	1 S	3 1	S S	8 5	S S	2	1	1			1	1	16	1					
		6/25	2 S	2 S	8 S	8 6	S S	5	5	5	2	NC	16	8	16						
		7/12	1 1	2 2	8 6	16 8	S S	5	5	5	3	NC	16	NC	NC						
4 wks	2E	6/26	S S	10 4	4 3	16 6	S S	11	11	5	5	5	5	1	1	5					
		7/10	S S	10 4	4 4	16 4	2 S	11	11	5	5	5	5	1	1						
Amiben AP	2S	6/4	16 10	16 3	16 3	16 7	9 4	5	4	2	1	1		1	1	16					
		6/25	16 2	16 S	16 6	16 7	4 4	4	1	6	4	1		7	7						
		7/11	16 16	16 16	16 16	16 16	8 4	4	1	4	1	1		1	1						
AP + irr	2S	6/4	16 2	10 2	6 2	16 6	S S	2	1	2	1	1		2	2	16					
		6/26	16 1	16 2	11 4	16 6	S S	2	1	3	2	1		2	2						
		7/10	16 2	16 4	16 16	16 15	S S	2	1	3	2	1		6	16						
4 wks	2S	6/26	16 3	16 S	16 S	16 16	S S	NC	NC	NC	NC	4	3	NC	NC	15					
		7/10	16 3	16 S	10 4	16 4	S S	NC	16	NC	16	1	1	NC	NC						
AP (14)	10G	6/4	14 7	14 3	14 1	14 11	S S	2	1	3	3	3	3	3	5	14					
		6/26	14 1	14 1	14 6	14 8	14 1	1	1	4	3	4	3	5	7						
		7/10	14 5	14 3	14 8	14 14	11 11	1	1	2	2	1	1	4	4						

Table 1 (Cont.)

Treatments ^{4/}	Obsv Date	Beans ^{5/} A ^{5/} B ^{6/}		T.Tom A B		S.Tom A B		S.Pot A B		Canta A B		Millet C ^{7/} D ^{8/}		Crab C D		Pigw C D		Native G B1		Oats 8/16
CDAA AP	4E	6/4	16 10	16 10	16 6	14 10	16 8	13 6	13 10	13 10	12 12	16								
		6/25	16 11	16 10	16 16	16 14	16 9	NC 16	NC 14	NC 16	16 16									
		7/12	16 16	16 16	16 16	16 15	16 16	NC 16	NC 16	NC 16	16 16									
CP 13936 AP	2E	6/4	10 S	6 1	6 1	10 2	16 1	5 4	- -	- -	1 1	16								
		6/25	10 S	10 S	6 S	16 2	8 S	6 5	- -	- -	1 1									
		7/12	10 S	16 6	7 S	16 6	6 6	6 6	- -	- -	16 16									
CP 17029 AP	2E	6/4	5 2	S S	S S	4 1	2 1	1	- -	- -	1 1	8								
		6/25	4 3	S S	S S	4 1	2 2	1	- -	- -	1 1									
		7/12	5 4	S S	S S	5 5	2 2	1	- -	- -	2 2									
CP 31675 AP	65W	6/4	2 S	1 S	1 S	16 10	4 S	2 1	- -	- -	1 1	16								
		6/25	2 S	6 S	2 S	16 4	2 S	2 1	- -	- -	1 1									
		7/12	4 2	6 S	4 2	16 16	4 2	2 2	- -	- -	1 1									
DCPA AP (24)	75W	6/4	24 11	24 5	3 2	24 24	24 2	24 19	2	3 2	2 2	6								
		6/25	24 15	24 9	S S	24 24	24 2	3 2	3 2	3 2	2 2									
		7/12	24 24	24 24	S S	24 24	11 11	3 3	3 3	3 3	2 2									
AP + irr (24)	75W	6/4	24 24	24 5	S S	24 20	S S	2	- -	- -	2 15	6								
		6/26	24 24	24 7	S S	24 20	S S	2	- -	- -	2 18									
		7/11	24 24	24 7	S S	24 20	S S	2	- -	- -	2 24									
Dichlobenil inc PP	50W	5/30	- -	S S	S S	1 1	- -	1	1	1	1 1	1								
		6/25	- -	1 S	S S	2 2	- -	1	1	1	4 4									
		7/10	- -	1 S	S S	2 2	- -	1	1	1	4 4									
AP	50W	6/4	5 S	10 S	S S	8 4	S S	3 2	1	1	1 1	8								
		6/25	5 4	14 4	S S	10 4	S S	3 2	1	1	4 4									
		7/12	5 2	11 6	S S	10 4	S S	3 2	3 3	1	2 2									
AP + irr	50W	6/4	S S	10 1	S S	1 S	S S	1	- -	- -	1 1	6								
		6/26	2 S	5 S	S S	2 S	S S	1	- -	- -	2 1									
		7/11	2 S	5 1	S S	3 2	S S	1	- -	- -	2 1									

Table 1 (Cont.)

57	Treatments ^{4/}		Obsv	Beans ^{5/}		T. Tom		S. Tom		S. Pot		Canta		Millet ^{7/}		Crab		Pigw		Native		Oats	R
			Date	A ^{2/}	B ^{6/}	A	B	A	B	A	B	A	B	C ^{7/}	D ^{8/}	C	D	C	D	G	Bl	8/16	10
	Dichlobenil	50W	6/26	16	4	16	S	10	S	16	2	16	4	NC	NC	-	-	-	-	NC	NC	10	1
		4 wks	7/10	16	S	16	S	10	S	16	S	16	2	NC	NC	-	-	-	-	NC	NC		
		4G	6/4	6	6	5	2	2	1	5	1	2	1	NC	6	-	-	-	-	1	1	6	
	AP (6)		6/26	6	6	5	2	2	1	2	S	1	1	NC	6	-	-	-	-	2	2		
			7/10	6	6	5	2	3	3	6	2	1	1	NC	6	-	-	-	-	-	-		
	Dinoben	2S	6/4	16	1	16	S	16	1	16	8	2	S	6	2	4	2	1		1	1	16	1
	AP		6/25	16	10	16	S	16	16	16	16	4	S	4	4	16	10	1		4	4		
			7/12	16	16	16	S	16	16	16	16	5	4	5	1	NC	16	1		6	6		
	Diphenamid	80W	6/4	-	-	16	10	16	6	16	10	16	6	4	3	3	1	7	6	1	1	8	1
	AP		6/25	-	-	16	8	16	6	16	16	16	4	4	3	2	2	4	2	1	1		
			7/12	-	-	16	16	16	16	16	16	16	6	4	1	2	2	1		1	1		
		80W	6/4	16	6	16	8	16	4	16	6	S	S	1		-	-	-	-	1	1	6	1
	AP + irr		6/26	16	4	16	6	16	16	16	10	S	S	2	1	-	-	-	-	1	1		
			7/11	16	5	16	10	16	16	16	10	S	S	2	1	-	-	-	-	1	2		
		80W	6/26	16	2	16	16	16	16	16	16	16	6	NC	NC	-	-	-	-	NC	NC	2	1
	4 wks		7/10	16	2	16	16	16	2	16	2	16	5	NC	NC	-	-	-	-	NC	NC		
	Diuron	80W	6/4	S	S	S	S	S	S	S	S	S	S	1		1		1		1	1	S	
	AP		6/25	S	S	S	S	S	S	S	S	S	S	1		1		1		1	1		
			7/12	S	S	S	S	S	S	S	S	S	S	1		1		1		1	1		
		80W	6/4	S	S	S	S	S	S	S	S	S	S	1		1		1		1	1	S	
	AP + (surf)		6/25	S	S	S	S	S	S	S	S	S	S	1		1		1		1	1		
			7/12	S	S	S	S	S	S	S	S	S	S	1		1		1		1	1		
	DNBP	3E	6/4	16	5	S	S	2	S	2	S	16	S	5	4	3	2	2	1	4	4	16	
	AP		6/25	16	6	S	S	2	S	2	S	3	S	5	5	4	3	6	6	6	6		
			7/12	16	11	S	S	3	2	2	S	2	2	15	4	15	15	15	15	16	16		

Table 1 (cont.)

Treatments ^{4/}	Obsv Date	Beans		T.Tom		S.Tom		S.Pot		Canta		Millet		Crab		Pigw		Native		Oats	Rye
		A ^{5/}	B ^{6/}	A	B	A	B	A	B	A	B	A	B	C	D	C	D	G	B1	8/16	10/3
DNBP AP + irr	3E 6/4	16	6	8	4	1	S	16	4	4	S	6	5	-	-	-	-	4	4	16	16
	6/26	16	16	8	4	1	S	16	6	4	S	NC	16	-	-	-	-	NC	NC		
	7/11	16	16	8	4	S	S	16	7	4	4	NC	6	-	-	-	-	NC	NC		
AP (10)	5.3G 6/4	2	1	4	2	1	S	10	5	1	S	7	5	-	-	-	-	1	1	3	16
	6/26	1	S	3	1	1	S	5	2	1	1	7	4	-	-	-	-	2	2		
	7/10	1	1	2	1	1	1	9	2	2	2	7	3	-	-	-	-	2	2		
FW 925 AP	2F 6/4	16	6	16	5	6	4	16	10	16	6	6	2	-	-	-	-	6	6	16	16
	6/25	16	8	16	6	8	4	16	10	16	6	8	4	-	-	-	-	12	12		
	7/12	16	16	16	16	16	9	16	16	16	13	6	3	-	-	-	-	16	16		
Hooker EG-TCA AP	4E 6/4	16	4	16	4	16	16	16	3	16	6	16	10	-	-	-	-	16	16	16	16
	6/25	16	S	16	6	16	16	16	6	16	6	11	11	-	-	-	-	16	16		
	7/12	16	S	16	S	16	16	16	16	16	16	11	11	-	-	-	-	16	16		
HP 7531 AP	80W 6/4	S	S	4	S	S	S	8	6	1	S	4	2	1		1		1	1	8	16
	6/25	2	S	4	2	S	S	8	4	S	S	6	4	5	4	6	5	4	4		
	7/12	2	S	4	4	S	S	8	8	S	S	6	6	6	6	6	6	6	6		
HS 119 AP	80W 6/4	S	S	2	S	S	S	2	S	S	S	4	3	2	1	2	1	1	1	7	16
	6/25	S	S	2	S	S	S	2	S	S	S	4	3	2	1	2	1	5	5		
	7/12	S	S	3	S	S	S	2	S	S	S	3	3	2	2	2	2	10	5		
Linuron AP	50W 6/4	S	S	S	S	S	S	4	4	S	S	1		1		1		1	1	4	8
	6/25	S	S	S	S	S	S	5	S	S	S	1		1		1		2	2		
	7/12	S	S	S	S	S	S	6	6	S	S	1		1		1		1	1		
AP+(surf)	50W 6/4	-	-	S	S	S	S	2	1	S	S	1		1		1		1	1	4	8
	6/25	-	-	S	S	S	S	2	S	S	S	1		1		1		3	3		
	7/12	-	-	S	S	S	S	2	2	S	S	1		1		1		4	4		
AP + irr	50W 6/4	S	S	1	S	S	S	10	5	S	S	1		-	-	-	-	1	1	4	6
	6/26	S	S	1	S	S	S	10	3	S	S	1		-	-	-	-	4	1		
	7/11	S	S	1	1	S	S	11	11	S	S	1		-	-	-	-	4	4		

Table 1 (cont.)

Treatments ^{4/}	Obsv Date	Beans		T.Tom		S.Tom		S.Pot		Canta		Millet		Crab		Pigw		Native		Oats 8/16	Rye 10/31
		A ^{5/}	B ^{6/}	A	B	A	B	A	B	A	B	C ^{7/}	D ^{8/}	C	D	C	D	G	Bl		
SD 7961 AP + irr	50W	6/4	S S	S S	S S	S S	S S	S S	S S	S S	1	1	1	1	1	1	1	1	1	2	3
		6/26	S S	S S	S S	S S	S S	S S	S S	S S	1	1	1	1	1	1	1	1	1		
		7/11	S S	S S	S S	S S	S S	S S	S S	S S	1	1	1	1	1	1	1	1	1		
AP (6)	10G	6/4	5 2	2 1	3 1	3 2	6 3	NC NC	NC NC	NC NC	NC NC	NC NC	NC NC	NC NC	-	-	-	-	5	6	
		6/26	6 3	2 2	4 4	3 S	5 3	NC NC	NC NC	NC NC	NC NC	NC NC	NC NC	NC NC	1	1	-	-			
		7/10	6 6	2 2	4 4	3 S	6 6	NC NC	NC NC	NC NC	NC NC	NC NC	NC NC	NC NC	1	1	-	-			
Stam F34 4 wks	3E	6/26	1 S	11 2	2 1	5 2	S S	4 2	6 4	2 1	4 4	16	16								
		7/10	1 S	11 6	2 1	9 2	S S	3 3	6 4	4 1	NC NC										
Svep AP	2E	6/4	10 4	8 2	4 S	16 6	S S	4 3	3 2	1	6 6	16	16								
		6/25	11 5	9 2	4 2	16 10	S S	4 3	4 2	8 8	9 9										
		7/12	11 11	9 4	4 2	16 16	S S	6 4	3 3	10 10	10 10										
AP (8)	5G	6/4	8 2	8 2	3 1	8 5	2 1	5 4	5 4	4 4	4 4	8	8								
		6/26	8 6	8 8	6 2	8 7	3 2	7 5	7 5	7 5	6 6										
		7/10	8 8	8 8	6 3	8 8	3 3	7 5	3 3	6 6	6 6										
Tordon AP (1)	2S	6/4	S S	S S	S S	.13 S	.22 S	1 .6	.36 .22	.08	1 .1	1	1								
		6/25	S S	S S	S S	S S	S S	1			1 .1										
		7/12	S S	S S	S S	S S	S S	NC 1	NC 1	NC 1	NC .5										
Trifluralin inc PP	4E	5/30	5 4	16 1	2 S	16 4	2 1	1	1	1	1 1	1	16								
		6/25	S S	16 2	S S	16 2	S S	1	1	1	1 1										
		7/10	S S	16 2	S S	14 2	S S	1	1	1	1 1										
AP	4E	6/4	- -	6 1	8 2	16 6	16 6	1	2 1	6 4	1 1	8	16								
		6/25	- -	- -	- -	16 10	16 16	1	3 2	3 2	1 8										
		7/12	- -	- -	6 5	16 16	16 16	1	3 2	3 2	1 8										
AP + irr	4E	6/4	- -	16 2	3 1	16 4	6 2	1	1	1	1 1	2	16								
		6/26	- -	16 6	2 1	16 4	6 2	1	1	1	1 2										
		7/11	- -	16 16	1 1	16 16	6 6	1	1	1	1 2										

Table 1 (Cont.)

Treatments ^{4/}	Obsv Date	Beans ^{5/}		T.Tom		S.Tom		S.Pot		Canta		Millet ^{7/8/}		Crab		Pigw		Native		Oats
		A	B	A	B	A	B	A	B	A	B	C	D	C	D	G	B1	8/16		
Trifluralin 5G AP (9)	6/4	-	-	9	6	9	6	9	9	9	9	NC	9	9	8	9	8	2	2	3
	6/26	-	-	9	9	9	9	9	9	9	9	9	7	9	7	9	7	3	3	
	7/10	-	-	9	9	9	9	9	3	9	9	6	3	8	8	9	9	7	7	
Zytron 2E AP	6/4	16	16	16	10	16	2	16	6	16	5	NC	16	-	-	-	-	5	5	16
	6/25	16	16	16	13	10	4	16	6	16	8	10	9	-	-	-	-	9	9	
	7/10	16	16	14	14	8	3	16	6	16	4	10	9	-	-	-	-	16	16	

- 1/ Horticultural crops planted May 6 were snap beans (Beans), transplanted tomatoes (T.Tom), direct seeded tomatoes (S.Tom), sweet potatoes (S.Pot) and cantaloupes (Canta).
- 2/ Oats were planted July 22 and the injury recorded on August 16. Rye was planted September 10 and the injury recorded October 31. The data are expressed as the highest rate as lbs AI/A at which there was no visible injury.
- 3/ German foxtail millet (Millet), crabgrass (Crab) and pigweed (Pigw) were seeded when the horticultural crops were planted. Control of native weeds (Native) was observed for grasses (G) and broadleaved weed (B1). The native grasses are crabgrass, goosegrass and lovegrass. Native broadleaved weeds are pigweed, lambsquarters, carpetweed and henbit.
- 4/ The herbicides were incorporated within 12 hours before planting (inc PP), applied to the surface with 24 hours after planting (AP) or applied to the surface 4 weeks after planting (4 wks). One set of AP plots were irrigated within 1 hour after herbicide application (AP + irr). The highest rate for all herbicides was 16 lbs AI/A unless noted in parenthesis () after the application method.
- 5/ A) The highest rate in lbs AI/A at which the crop remained alive.
- 6/ B) The rate in lbs AI/A at which the crop showed no visible injury symptoms. "S" indicates that the crop was sensitive at the lowest rate applied.
- 7/ C) Rate in lbs AI/A necessary for 100% control. "NC" indicates no control at the highest rate applied. A dash (-) indicates planted weeds did not emerge in the untreated area as a result of improper seeding depth.
- 8/ D) Rate in lbs AI/A necessary for 90% control.

Chemical Weeding of Parsley

Charles J. Noll

Many of the commercial canners in Pennsylvania use parsley for flavoring. The parsley used is shipped into the state usually as a frozen product. We were asked to investigate the possibility of growing parsley within the state. Probably the biggest obstacle to growing the crop is weed control. To solve this problem the following experiment was conducted.

Procedure

The seedbed was prepared, pre-planting treatments applied and incorporated and seeds planted May 2. The pre-planting treatment was applied as a spray and incorporated in the soil with a rototiller set shallow. The variety seeded was Perfection. The pre-emergence treatments were applied either 5 or 10 days after seeding and the post-emergence treatments 29 or 35 days after seeding. Individual plots were 20 feet long and 2 feet wide. Treatments were randomized in each of 5 blocks.

The chemicals were applied over the row with a small sprayer for a width of 2 feet in the pre-planting treatments and 1 foot for the pre- and post-emergence treatments. Cultivation controlled the weeds between the rows. An estimate of weed control was made July 2 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Irrigation was applied during the season. Two harvests were made, the first August 3 and the second October 2.

Results

The results are presented in Table 1. A number of chemicals gave excellent weed control: trifluralin at 2, 4, 6 pounds per acre in the pre-planting soil incorporation treatment, amiben, prometryne and sweep in a pre-emergence treatment, and sweep, solan and Stoddard Solvent in a post-emergence treatment. In general the lighter rate of chemical used where weed control was adequate gave the best yield. Although sweep at 6 lbs. per acre applied 10 days after seeding gave the best total yield, the yield was not significantly better than in plots treated with trifluralin at 2 lbs. per acre prior to planting and incorporated or amiben at 6 and 12 pounds or prometryne at 2 pounds per acre applied prior to parsley emergence.

Conclusion

A number of chemicals are promising for the weeding of parsley. These are sweep, trifluralin, amiben and prometryne. Certainly the best of them after more extensive trials and clearance could be used to weed this crop.

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Table 1. Weed Control and Yield of Parsley under Chemical Herbicide Treatments

Treatment	Active Rate per Acre lbs.	Application Days from Planting		*Weed Control (1-10)	AVERAGE PER PLC	
					First	Total
1 Nothing	--	--	--	9.8	.1	
2 Trifluralin	2	Inc.	- 0	2.4	3.6	11
3 "	4	"	- 0	2.2	2.8	5
4 "	6	"	- 0	2.0	2.0	7
5 SD 6623	8	"	- 0	8.6	.0	
6 "	8	Pre	+ 5	7.4	.2	
7 Amiben	6	"	+ 5	1.2	3.8	11
8 "	12	"	+ 5	1.0	3.6	11
9 Prometryne	2	"	+ 5	2.8	4.6	11
10 "	4	"	+ 5	1.2	3.3	10
11 Swep	6	"	+10	1.6	5.3	15
12 "	3	Post	+29	2.8	3.0	8
13 Solar	6	"	+29	2.0	3.4	10
14 Stoddard Solvent	75 gal.	"	+35	2.8	1.3	4
Least significant difference 5%				1.1	1.8	4
1%				1.5	2.4	0

*Weed Control 1-10: 1 Perfect Weed Control
10 Full Weed Growth

WEED CONTROL IN SPINACH AND CERTAIN SALAD AND LEAFY CROPS

B. M. Metzger, R. D. Ilnicki,
J. F. Ellis, and W. H. Tharrington¹

During the past five years the New Jersey acreage of fall and spring seeded fresh market spinach has remained constant at 1,400 acres. The production from this acreage has accounted for 18 percent of the total production of fresh market spinach in the United States. Accordingly, New Jersey has ranked second only to Texas in the production of fresh market spinach (1).

Of the several herbicides recommended for use on spinach and certain salad and leafy crops, no one has produced results of optimum satisfaction. If the problem of weed contaminations could be eliminated then the full value of mechanical harvesters might be realized by producers. Since the weed spectrum for fall seedings, henbit (Lamium amplexicaule) and chickweed (Stellaria media), differs from that for spring seedings, pigweed (Amaranthus retroflexus), lambsquarter (Chenopodium album), and foxtail (Setaria spp.), experiments have been in progress with fall and spring seedings.

Materials and Methods

Over a three-year period experiments have been carried out at Seabrook, New Jersey in cooperation with Seabrook Farms Co. and at the New Jersey Agricultural Experiment Station at Adelphia on sandy loam soils.

The herbicides applied and the time of their application were:

- (a) 1-phenyl-4-amino-5-chloropyradazone-[6] (Pyramin, ACP-215 or ACP-215-A) -- applied as a wettable powder (80W) at the rates of 1, 2, and 4 pounds per acre as pre-emergence treatments in the fall and spring.
- (b) 1-phenyl-4-amino-5-chloropyradazone-[6] (Pyramin, ACP-215-B) -- applied as a wettable powder (50W) at the rates of 1, 2, and 4 pounds per acre as pre-emergence treatments in the spring.

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- (c) 2-chloro-N,N-diallylacetamide (CDAA) plus 2-chloroallyl-diethylthiocarbamate (CDEC) -- applied as emulsifiable concentrates at the rates of 2-1/2 + 2-1/2 and 3 + 3 pounds per acre as fall and spring pre-emergence treatments.
- (d) methyl-0-nitrophenyl sulfide (CP-13936) -- applied as an emulsifiable concentrate at the rates of 4, 5, and 6 pounds per acre as fall and spring pre-emergence treatments.
- (e) Dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) -- applied as a wettable powder (75W) at the rates of 4, 6, 8, and 24 pounds per acre as fall and spring pre-emergence treatments and as a spring pre-plant treatment.
- (f) 2,4-dichlorophenyl-4-nitrophenyl ether (TOK) -- applied as an emulsifiable concentrate at the rates of 2, 4, 6, and 8 pounds per acre as fall and spring pre-emergence treatments.
- (g) 2,6-dinitro-N,N-di-n-propyl-a,a,a-trifluoro-p-toluidine (trifluralin) -- applied as an emulsifiable concentrate at the rates of 1/2, 1, 3, 4, 5, and 6 pounds per acre as fall and spring pre-plant and pre-emergence treatments.

The herbicidal sprays were applied with a bicycle sprayer as described by Shaw (2) and a knapsack-type sprayer at 30 psi pressure and at the rate of 40 gallons of water per acre.

Spring seedings were made on April 16th and 23rd, in addition to a late spring seeding on June 1st. Ratings of weed control and crop injury were made between 38 and 42 days after planting. Fall seedings were planted on August 29th and rated 42 days after planting for weed control and crop injury.

The crops treated were as follows: Spinach - Savoy Supreme and Badger Savoy; Collards - Georgia Southern and Vates; Turnip Greens - Shogoin and Seven Top; and Broccoli Raab.

Results and Discussions

ACP-215 or ACP-215-A

Fall pre-emergence applications at rates of 1 and 2 pounds per acre produced no crop injury to spinach; however, the 3-pound rate did produce crop injury as did all rates on collards, turnip greens and broccoli raab. Broadleaf weed control was better than that of grasses at all rates. Control from the

Spring pre-emergence applications at rates of 1, 2, and 4 pounds per acre produced results similar to fall treatments with the exception that there was more spinach injury at comparable rates.

ACP-215-B

Spring pre-emergence applications at rates of 2 and 4 pounds per acre produced weed control comparable to that of ACP-215 and ACP-215-A but caused extensive crop injury to spinach.

CDA + CDEC

Fall and spring pre-emergence applications at rates of 2-1/2 + 2-1/2 and 3 + 3 pounds per acre yielded comparable excellent weed control. Both grasses and broadleaf weeds were controlled. All fall seedings demonstrated a complete tolerance to the combinations.

The spring seedings of spinach and broccoli raab appeared as highly tolerant species while the collards and turnip greens demonstrated only fair tolerance.

CP-13936

As a fall pre-emergence treatment, CP-13936 produced excellent broadleaf and grass control and caused no crop injury to spinach. Collards, broccoli raab, and turnip greens exhibited little tolerance to the compound.

In the spring seedings, the weed control was less than excellent and the crop injury to all crops more severe.

DCPA

Fall pre-emergence treatments at the rates of 8 and 24 pounds per acre yielded excellent broadleaf and grass control. Crop injury was absent in all crops treated at the 8-pound rate but at the 24-pound rate there was moderate spinach injury.

Spring pre-emergence treatments at the rates of 4, 6, 8, and 24 pounds per acre produced excellent broadleaf and grass control. Crop tolerance was good to excellent for collards, turnip greens and broccoli raab but that of spinach only fair to good.

Spring at-emergence treatments at rates of 8 and 24 pounds produced less effective weed control than pre-emergence treatments. Spinach injury was reduced in the at-emergence treatments but not in collards, turnip greens or broccoli raab.

TOK

Fall pre-emergence treatments at rates of 2, 4, and 6 pounds per acre yielded comparable excellent weed control with slightly better control of grasses than broadleaves. Broccoli raab and turnip greens were highly tolerant to all rates tested. Collards showed a lesser degree of tolerance at the highest rate and spinach was only moderately tolerant at the 2-pound rate.

Spring pre-emergence treatments proved to produce slightly less weed control and in all cases was more toxic to crop species than the fall treatments.

Trifluralin

Fall pre-plant treatments produced excellent weed control at all rates. Crop tolerance for all crops was high at the 1/2-pound rate and at the 1-pound rate for turnip greens, broccoli raab, and collards. Fall pre-emergence treatments produced comparable weed control. Crop injury was reduced at rates of 4 and 6 pounds from that obtained with the pre-plant treatments.

Spring pre-plant treatments produced fair weed control with considerable crop injury. Spring pre-emergence treatments also yielded only fair weed control with considerable crop injury.

Summary

Spinach, collards, turnip greens, and broccoli raab received fall and spring pre-plant and pre-emergence treatments, the results of which were evaluated.

ACP-215, ACP-215-A, CDAA + CDEC, CP-13936, DCPA, and trifluralin applied to spinach gave good weed control with minimal crop injury

CDAA + CDEC, DCPA, TOK, and trifluralin were compounds which when applied to collards, turnip greens and broccoli raab produced good weed control with no crop injury.

Literature Cited

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Preliminary Studies with Combinations of Solan and Paraquat
in Field Seeded Tomatoes^{1/}

J. C. Cialone^{2/} and D. W. Davis^{3/}

Solan is used as a post-emergence herbicide for the control of broadleaved weeds in transplanted tomatoes. The main weakness of Solan is in the control of annual grass species. For this reason it has not gained general acceptance.

Colby and Warren (1,2) have reported that combinations of Solan and Paraquat have given satisfactory control of broadleaf and grass species with little tomato injury. They found increased tomato tolerance and greater activity on crabgrass when these two chemicals were used in combination, than when either was used alone.

Colby (2) indicated that rates of 1-2 pounds per acre of Solan with 0.025-0.5 lbs/A Paraquat looked promising in field studies. Paraquat at certain rates is an extremely active post-emergence herbicide but tomato tolerance can be obtained only at lower rates.

The objectives of the work reported here were to determine the effect of rates, ratios, method of application and wetting agents on the activity and selectivity of Solan-Paraquat combinations.

Experimental

Tomatoes (var. Fireball) and Barnyardgrass (*Echinochloa crus-galli*) were field seeded in paired rows, 1 pair in each plot, on a gravelly loam soil. Solan and Paraquat were applied at several stages of growth of the test species ranging from when they were 3-4 inches tall through to when both were 2 feet tall. Rates, ratios, and combinations of Solan and Paraquat with wetting agents were studied using a small plot, logarithmic sprayer. In addition, comparisons were made of a conventional CO₂-sprayer with a small "air blast" sprayer.

Rates and Ratios

The first treatments were applied when tomatoes and barnyardgrass were 3-6 inches tall. The results of this test are given in table 1. It is obvious from the data that the combination of Solan and Paraquat was much more active on barnyard grass than either of the chemicals alone at comparable rates. Tomato injury from the combination treatment was very slight and control of both barnyardgrass and broad leaved weeds was excellent.

In a later test tomatoes and barnyardgrass were 12-16 inches tall when treatments were applied. The results are given in Table 2. It can be seen that tomato was susceptible to rates of more than .025 lbs/A Paraquat alone, and this susceptibility was lessened when Solan was added at 1,2, or 4 lb/A.

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Table 1. Results of Solan-Paraquat Applications on Tomato and Barnyardgrass.

<u>Chemical</u>	<u>lbs/acre</u>	<u>Tomato</u>	<u>Barnyardgrass</u>	<u>Lambsquarters</u>
Solan	logged 4 to 1/4	No injury	No control	Kill at all rates
Paraquat	logged 0.1 to 0.005	No injury	No control	No control
Solan+Paraquat	2 constant & logged 0.1 to .005	Stunted to .05 Paraquat	Kill to .06 Paraquat	Kill at all rates

Table 2. The effect on tomato and barnyardgrass of adding Solan at various rates to logarithmic applications of Paraquat.

<u>Chemical</u>	<u>lbs/acre</u>	<u>Tomato</u>	<u>Barnyardgrass</u>
Solan+Paraquat	4 constant+logged	0.4 to 0.025	Injury to .05
"	2 " + "	" "	" " .05
"	1 " + "	" "	" " .04
Solan	logged 8 to 1/2	" "	" " 4
Paraquat	logged 0.4 to 0.025	" "	" " .025
			" " 2
			" " 0.3

Method of application

When the tomatoes and barnyardgrass were 10-12 inches tall Solan-Paraquat combinations were applied using a boom sprayer and a back pack-motor powered "air blast" sprayer. Since the CO₂ sprayer has relatively large droplets and sprays are deposited primarily on the upper surfaces of plants, the air blast apparatus was included to determine if smaller droplet size and coverage of both upper and lower leaf surfaces would materially influence the results. It can be seen from the data in table 3 that at the rates used there were no significant differences between the two methods of application. Furthermore, uniform application was not obtained with the air blast sprayer. Individual plants showed severe damage whereas others showed none. This aspect of the problem needs more study.

Table 3. Results of boom sprayer and "air blast" sprayer applications of Solan-Paraquat combinations.

<u>Chemical</u>	<u>lbs/acre</u>	<u>Appl. Method</u>	<u>Tomato</u> ^{1/}	<u>Barnyardgrass</u> ^{2/}
Solan+Paraquat	4 + 0.2	Boom sprayer	3.5	9.0
Solan+Paraquat	4 + 0.2	"air blast"	4.5	8.7

^{1/} 9 = perfect crop. 1 = crop killed.

^{2/} 9 = perfect weed control. 1 = no control.

Wetting Agents

In several tests experimental adjuvants, Atlas 206, 209 and 210 were applied with Solan and Paraquat alone and in combination. Straight dosage and logarithmic applications were made in the rate range of 2.0 to 0.10 percent of the spray volume. The adjuvants were non phytotoxic at the rates used. Although in several tests slight increases in activity of Solan and Paraquat resulted with the addition of adjuvants, these increases were not clear cut nor readily reproducible.

Summary

Results of preliminary investigations indicate that Solan-Paraquat combinations are more effective in controlling barnyardgrass than either herbicide alone at comparable rates. Although tomato tolerance was somewhat variable from test to test and could not be evaluated specifically, Solan-Paraquat combinations do offer excellent potential for commercial control of annual grasses and broadleaves in this crop. It is felt that both rates, timing, and other factors require further investigation.

Literature Citations

1. Colby, S. R. and G. F. Warren, *Herbicides: Combination enhances selectivity.* Science Vol. 41, No. 3578, July, 1963.
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TOMATO RESPONSES FROM FOLIAR APPLICATION
OF VARIOUS AMIBEN AND DINO BEN FORMULATIONS

R. D. Hart and A. R. Cooke¹

Amiben (3-amino-2,5-dichlorobenzoic acid) as the ammonium salt, 10% active on 24/48 attaclay, has been tested extensively for weed control in transplanted tomatoes and is cleared in the United States for this use. Amiben is used primarily as a pre-emergence herbicide, but as a foliar spray it affects certain plants, especially annual broadleaf ones. Formulation on granules has reduced this post-emergence activity to the point that transplanted tomatoes seldom show any evidence of response to foliage applications.

Preliminary studies several years ago suggested that dinoben sprays had less foliar activity than amiben sprays, but most workers using both in granular form have indicated that amiben appears safer on tomatoes.

Tests were set up during 1963 to re-observe the responses of tomatoes to amiben and dinoben formulations available in the past and also evaluate new granular formulations, particularly of amiben, which might provide even greater safety for weed control in transplanted tomatoes.

TEST I. Comparison of amiben and dinoben sprays with various size granular formulations for weed control in transplanted tomatoes.

Procedure

Jersey Campbell Soup #146 tomatoes, bare root, were set on May 29, 1963. The area was cultivated and hoed and poor or dead plants replaced on June 14, 1963. Treatments replicated three times were applied on June 17 to 3' x 12' plots each containing six tomato plants.

Since it seems reasonable to speculate that the most dangerous conditions under which a farmer might apply granular amiben would be when the tomato foliage was wet from rain or dew, and since it was necessary to try to obtain at least some injury from the granular materials to determine whether one was safer than another, the foliage of the plants was wet with water just prior to application of all granular treatments.

Results

Recorded observations are summarized in Table 1. Eighteen hours after application, all formulations of amiben had caused epinasty. The amount of epinasty decreased as the size of the granules increased. After about a week only slight indications of this initial epinasty from the amiben formulations could be detected and this was gone after about two weeks. Although the 24/48

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granular form of dinoben did cause some response after 18 hours, it was primarily a cupping of the leaves and not a bending of the petioles and stems as caused by the amiben formulations.

Leaf cupping apparently due to dry weather and/or aphid injury made it difficult to evaluate the leaf malformation from the treatments 68 days after application. No treatment had caused more than questionable to slight leaf abnormality. All formulations of amiben and dinoben produced good weed control.

TEST II. Comparison of weed and tomato response to amiben acid and amiben ammonium salt on various size granules.

Procedure

Greenhouse potted Campbell Soup #146 tomatoes with balls of dirt were set in the field on August 12, 1963. Treatments replicated four times were made on August 15, 1963, to 3' x 12' plots each containing five plants. The ammonium salt of amiben on 24/48 attack was applied to both wet and dry foliage; all other granular treatments were applied to wet foliage only.

Results

Table 2 indicates the relative amount of response noted 24 hours, 8 days and 40 days after application of the treatments. After 24 hours there was considerable difference in the epinasty produced by the various treatments, but even the most severely affected plants had completely recovered after 8 days. After 40 days there were four plots in which the plants appeared to have slightly less dense foliage; three of these plots received the ammonium salt on 15/30 attack and the fourth received the ammonium salt on 24/48 attack.

Percent weed control produced by all treatments was too high to show any difference between formulations.

TEST III. Comparison of various samples and formulations of dinoben.

Procedure

Greenhouse potted Campbell Soup #146 tomatoes with balls of dirt were set in the field on August 12, 1963. Treatments replicated twice were made on August 5, 1963, to 3' x 12' plots each containing five plants.

Results

No response (see Table 3) was noted from any of the treatments the next day, but in about 40 days treatments with two samples produced several years ago had caused considerable leaf malformation. The 1963 material available to research workers caused only slight leaf malformation.

SUMMARY

1. The type and degree of tomato response noted from amiben and dinoben sprays depends largely on when observations are made. Within 24 hours, amiben causes considerable epinasty, but this disappears in a week or two with no apparent effect on subsequent growth. Dinoben, in contrast, causes little to no epinasty. However, either amiben or dinoben may produce abnormally-shaped leaves or spindly over-all plant growth periodically, or sometimes continually after several weeks and throughout subsequent growth. This is particularly true of dinoben samples with a low melting point.
2. Considerable epinasty can result from application of 24/48 granular amiben to tomatoes with wet foliage. The amount of this epinasty can be decreased by increasing the size of the granules.
3. There appears to be no major difference between comparable granular formulations of amiben acid and amiben ammonium salt in the response of tomatoes or the weed control produced.
4. Present results indicate that for use on transplanted tomatoes, reduced likelihood of epinasty makes 10% formulation of amiben on 8/15 or 15/30 mesh attaclay preferable to 24/48 mesh. However, there is no indication that 24/48 mesh granules cause permanent injury.

TABLE 1. Response of transplanted tomatoes to liquid and various granular applications of amiben to wet foliage.

Treatment (at 4 lb/A active)		Average for 3 replications			
		Tomato response		Visual estimate of percent weed control — 52 days	
		Epinasty* 18 hours	Leaf malformation* 68 days	Grass**	Broadleaf**
Amiben	liquid ammonium salt	4.6	1.0	92	94
Amiben	10% granular on 24/48 attaclay (ammonium salt)	3.6	1.0	98	99
Amiben	10% granular on 15/30 attaclay (ammonium salt)	3.0	1.0	98	98
Amiben	10% granular on 8/15 attaclay (ammonium salt)	1.3	1.6	98	96
Dinoben	liquid sodium salt	0	1.0	96	97
Dinoben	10% granular on 24/48 attaclay (sodium salt)	1.0	2.0	92	97
Dinoben	10% granular on 15/30 attaclay (sodium salt)	0	1.0	93	95
Dinoben	10% granular on 8/15 attaclay (sodium salt)	0	1.6	92	96

* 0 = none; 1 = questionable; 2 = slight; 3 to 4 = moderate; 5 = severe.

** Mostly foxtail (Setaria faberii);
light stands of ragweed, pigweed and lambsquarters.

TABLE 2. Response of weeds and tomatoes to acid and ammonium salt formulations of amiben on various size granules.

<u>Treatment (at 4 lb/A active)</u>	<u>Visible effects</u>			<u>Weed control***</u>	
	<u>8/16</u>	<u>8/23</u>	<u>9/25</u>	<u>Broadleaf</u>	<u>Grass</u>
Liquid ammonium salt	5.0*	0	0	99.5	99.0
10% granular on 24/48 attaclay (ammonium salt) wet foliage	3.0	0	.25**	100.0	99.25
10% granular on 24/48 attaclay (ammonium salt) dry foliage	1.0	0	0	100.0	98.5
10% granular on 15/30 attaclay (ammonium salt) wet foliage	2.0	0	.75**	99.75	99.25
10% granular on 8/15 attaclay (ammonium salt) wet foliage	0.5	0	0	99.5	97.25
10% granular on 24/48 attaclay (acid) wet foliage	3.0	0	0	99.0	99.0
10% granular on 15/30 attaclay (acid) wet foliage	2.5	0	0	99.75	98.5
10% granular on 8/15 attaclay (acid) wet foliage	0.5	0	0	99.5	96.0

* 0 = plants apparently normal; 5 = severe epinasty.

** Plants appeared slightly stunted and/or with reduced amount of foliage.

*** Light stands of lambsquarters and foxtail.

TABLE 3. Response of tomato transplants and weeds to various samples and formulations of dinoben.

<u>treatment (at 4 lb/A active)</u>	<u>Carrier</u>	<u>8/16 Epinasty*</u>	<u>9/25 Leaf malformation*</u>	<u>Weed control**</u>	
				<u>Broadleaf</u>	<u>Grass</u>
d, mp 219-220°C.	ethyl alcohol & water	0	0	98.0	98.5
d, mp 220-221°C.	ethyl alcohol & water	0	0	100.0	97.5
d, mp 214-217°C.	ethyl alcohol & water	0	0.50	99.0	97.5
d, mp 214-217°C.	1N sodium hydroxide & water	0	0.25	99.0	98.0
3, sodium salt	water	0	3.00	97.5	97.5
9 acid, mp 189-206°C.	ethyl alcohol & water	0	5.00	100.0	100.0
3 2 lb/gal sodium salt	water	0	0.50	100.0	99.5
3 sodium salt (on wet foliage)	24/48 granular	0	0.75	96.0	98.5

0 = plant apparently normal; 5 = severe effect.

Light stand of lambsquarters and foxtail.

EFFECT OF SEVERAL HERBICIDE TREATMENTS ON YIELD AND PLANT GROWTH OF TRANSPLANTED SUCCESS TOMATOES

Oscar E. Schubert and Keith E. Harbert¹

The weed control problem in West Virginia tomato fields is neither primarily that of grassy weeds nor broadleaf weeds but a combination of many of each kind. For this reason, successful herbicide treatments must be able to control both types, else be doomed to failure since the uncontrolled kind will rapidly cover the field after completion has been decreased. The primary purpose of this experiment was to control grassy and broadleaf weeds with herbicides from the time of transplanting until after tomato harvest by use of pre-emergent and post-emergent herbicides.

METHODS AND MATERIALS

The site chosen for the experiment was near some of the commercial tomato producing areas in Morgan County, West Virginia. Success tomato plants were transplanted from flats grown at the University Greenhouse into the freshly cultivated field on May 22, 1963. After setting, the tomato plants were watered with one cup of a starter solution prepared by adding 6 pounds of a commercial 10-52-17 fertilizer to 100 gallons of water. The field was divided into 40 plots 12 feet wide and 15 feet long allowing 4 replications of each treatment. In the center of each plot 24 plants were set 15 inches apart in rows 4 feet apart thus leaving a 2.5 foot buffer strip unplanted at both ends.

The pre-emergent herbicides of treatments 2,3,4,5,7,8, and 9 were applied on May 23 and 24. Tillam of treatment 6 was applied on May 27. Since growing conditions for weeds were favorable in late May and early June, the grasses were too large for control by solan; therefore, plots to receive treatments 10,11, and 12 were hoed on June 11. By June 20, the grasses were about one-inch in height in these plots, and herbicides were applied to treatments 10, 11, and 12. On June 26, grasses and weeds were emerging in several plots of treatments 1 through 9 and these plots were given the planned lay-by application of solan and treatments 10, 11, and 12 were given the second (or lay-by) application of solan. The herbicide treatments with application dates are given in Table I.

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The co-operation of the following companies in supplying the herbicides used in this experiment is gratefully acknowledged. Amchem Products, Inc., California Chemical Company, Eli Lilly and Company, Niagara Chemical Division of the Food Machinery and Chemical Corporation, and Stauffer Chemical Company.

Table 1. Herbicide treatments applied to transplanted Success tomato plants in 1963.

Treatment Number	Herbicide and Formulation	Rate in lb/A	Dates of application P.E.	Lay-by
1	Hoed + Solan, ec	4		June 26
2	Diphenamid, wp+ Solan, ec	5 + 4	May 24	June 26
3	Diphenamid, wp+ Swep, G+ Solan, ec	5 + 6 + 4	May 24	June 26
4	Diphenamid, wp+ Dinoben, G+ Solan, ec	5 + 4 +	May 24	June 26
5	Swep, G + Solan, ec	6 + 4	May 23	June 26
6	Tillam, G + Solan, ec	5 + 4	May 27	June 26
7	Amiben, G + Solan, ec	4 + 4	May 23	June 26
8	Dinoben, G + Solan, ec	4 + 4	May 23	June 26
9	Dinoben, ec + Solan, ec	4 + 4	May 24	June 26
10	Solan, ec + Solan, ec	4 + 4	June 20	June 26
11	Solan, ec + Paraquat, ec + Solan, ec	2 + 0.1 + 4	June 20	June 26
12	Solan, ec + Diphenamid, wp+ Solan, ec	4 + 3 + 4	June 20	June 26

RESULTS AND DISCUSSION

Statistical Analyses

All data were analyzed statistically by an analysis of variance and the treatment means were compared at the 5% level of significance using Tukey's test of "All Comparisons Among Means", as described by Snedecor.

Marketable Yield of Tomatoes

The tomatoes were harvested during August and sorted into two lots (marketable and unmarketable). The marketable classification included all sound, well-formed tomatoes weighing a minimum of 4 ounces. All other tomatoes were considered unmarketable. Treatment 1, which was hoed except for one topical spray of solan, had higher yields of marketable tomatoes (Table 2) than treatments 4 (diphenamid + dinoben, G + solan), 6 (tillam + solan), 7 (amiben, G + solan), 8 (dinoben, G + solan), and 9 (dinoben, ec + solan). Treatment 12 (solan + diphenamid + solan) had higher yields than treatments 4, 6, 8, and 9. Treatment 11 (solan + paraquat + solan) had higher yield than treatments 4 and 8 while treatment 10 (solan + solan) was higher than treatment 8 only. The foregoing indicates a decrease in total yield from dinoben (G and ec).

Total Yield of Tomatoes

Treatment 1 had higher total yields (Table 2) than treatments 4, 6, 7, 8, and 9 plus treatments 3 (diphenamid + swep + solan) and 5 (swep + solan). Treatments 10, 11, and 12 had higher yields than treatments 3, 4, 5, 8, and 9. Total yields of treatments given dinoben or swep were lower than treatments 1, 10, 11, and 12.

Fresh Weight of Tomato Tops and Roots

Tomato plants were pulled and divided into two parts (tops and roots) at the soil line and weighed after removing loose soil from the roots.

Although plants in some treatments had lower weights of tops and roots and plants in the field appeared dwarfed, there were not enough observations (weights) to establish a difference between herbicide treatments at the 5% level of significance.

Appearance of Plants

Leaves of tomato plants in treatments 4 (diphenamid + dinoben, G + solan) and 8 (dinoben, ec + solan) exhibited symptoms similar to 2,4-D injury symptoms on tomato leaves. Tomato plants in treatment 9 (dinoben, ec + solan) did not show any injured or malformed leaves. Apparently dinoben as a granule has a higher level of toxicity to tomatoes under the conditions existing in the field, than dinoben in an emulsifiable concentrate formulation. Plants in treatments 3 and 5 (where swep was included) appeared dwarfed in comparison with plants

Table 2. Effect of herbicide treatments on marketable yield, total yield, top-weight, and root-weight of Success tomato plants (average per center record plot of 8 original plants).

No.	Treatment Herbicides Applied	Yield of tomatoes		Fresh weight Tomatoes	
		Marketable lbs.	Total lbs.	Tops lbs.	Roots lbs.
1	Hoed + Solan	25.6 a	53.0 a	11.0 a	1.6 a
2	Diphenamid + Solan	15.8 ae	40.4 ac	12.2 a	2.2 a
3	Diphenamid + Swep + Solan	16.5 ae	27.1 c	8.6 a	1.4 a
4	Diphenamid + Dinoben,G+ Solan	8.5 de	28.7 c	10.0 a	2.2 a
5	Swep + Solan	15.7 ae	28.6 c	8.2 a	1.4 a
6	Tillam + Solan	11.4 ce	32.4 bc	9.2 a	1.8 a
7	Amiben,G + Solan	12.3 be	32.2 bc	7.7 a	1.6 a
8	Dinoben,G + Solan	6.8 e	28.3 c	8.6 a	2.0 a
9	Dinoben, ec + Solan	11.4 ce	28.3 c	8.7 a	1.8 a
10	Solan + Solan	19.7 ad	48.0 ab	10.2 a	1.6 a
11	Solan + Paraquat + Solan	20.9 ac	48.4 ab	9.5 a	1.8 a
12	Solan + Diphenamid + Solan	23.4 ab	50.2 ab	10.2 a	1.9 a
		D=11.8	D=18.3	D=5.2	D= 1.4

Treatment averages followed by the same letter are not significantly different (at the 5% level) from each other using Tukey's test of "All Comparisons Among Means" as described by Snedecor.

Weights of Grassy and Broadleaf Weeds

All weeds were pulled, and shaken off, sorted into grassy and broadleaf weeds and weighed in the field.

Treatment 6 (tillam + solan) gave the poorest control of grassy weeds (Table 3). Inasmuch as the differences in grassy weed control were so marked it may be assumed that tillam was either not properly incorporated for optimum effects or soil moisture relationships favored the loss of tillam with water vapor.

Treatments 3 (diphenamid + swep + solan), 4 (diphenamid + dinoben, G + solan), 12 (solan + diphenamid + solan), and 1 (hoed + solan) had smaller weights of weeds than treatment 6 (tillam + solan). In most plots the herbicide treatments controlled broadleaf weeds satisfactorily.

Number of Grassy and Broadleaf Weeds

The weeds were sorted into grassy and broadleaf weeds and counted. The counts were transformed by adding 1 to the count and extracting the square root before statistical analyses were made. Small weeds (that had recently emerged or made little growth) were not counted or weighed after the yields of several plots was only a few grams of small weeds.

Treatments 2 (diphenamid + solan) 3 (diphenamid + swep + solan), 4 (diphenamid + dinoben + solan), and 1 (hoed + solan) had smaller numbers of grassy weeds than treatments 6 (tillam + solan), 7 (amiben, G + solan), and 8 (dinoben, G + solan). Treatments 2, 3, 4, 5 (swep + solan), 9 (dinoben, ec + solan), 10 (solan + solan), and 11 (solan + paraquat + solan) also had smaller numbers of grassy weeds than treatment 6.

No significant differences were noted between numbers of broadleaf weeds in any of the herbicide treatments.

SUMMARY

Success tomato plants given herbicide treatments one month after setting--Treatments 1 (hoed + solan), 10 (solan + solan), 11 (solan + paraquat + solan), and 12 (solan + diphenamid + solan) produced higher total yields than treatments 3 (diphenamid + swep + solan), 5 (swep + solan), 4 (diphenamid + dinoben, G + solan), 8 (dinoben, G + solan) and 9 (dinoben, ec + solan).

The weights of tomato tops and roots were not significantly reduced over other treatments by any of the herbicide treatments.

Tomato plants from treatments 4 and 8, both having dinoben in the granular formulation, exhibited leaves with injury similar to that of 2,4-D.

Table 3. Effect of herbicide treatments on weights and number of grassy and broadleaf weeds in a planting of Success tomatoes (average per center record plot of 80 square feet).

No.	Treatment Herbicides Applied	Fresh weight of weeds		Number of weeds	
		Grass lbs.	Broadleaf lbs.	Grasses	Broadleaf
1	Hoed + Solan	0.00 a	0.00 a	0 a	0 a
2	Diphenamid + Solan	0.22 a	0.45 ab	2 a	1 a
3	Diphenamid + Swep + Solan	0.02 a	0.00 a	1 a	1 a
4	Diphenamid + Dinoben,G+ Solan	0.00 a	0.08 a	0 a	3 a
5	Swep + Solan	1.28 a	0.15 ab	16 ab	2 a
6	Tillam + Solan	16.30 b	4.68 b	116 c	19 a
7	Amiben, G + Solan	6.62 a	1.02 ab	57 bc	17 a
8	Dinoben, G + Solan	3.65 a	2.48 ab	64 bc	35 a
9	Dinoben, ec + Solan	2.22 a	0.25 ab	21 ab	11 a
10	Solan + Solan	3.05 a	0.52 ab	24 ab	4 a
11	Solan + Paraquat + Solan	1.08 a	0.45 ab	21 ab	3 a
12	Solan + Diphenamid + Solan	2.92 a	0.05 a	35 ac	4 a

D=8.75 D=4.57

Treatment averages followed by the same letter are not significantly different (at the 5% level) from each other using Tukey's test of "All Comparisons Among Means" as described by Snedecor.

Chemical Weeding of Tomatoes

Charles J. Noll

The acreage of direct seeded tomatoes is increasing in Pennsylvania, especially in areas with long growing seasons. Direct seeding reduces the planting costs but inadequate weed control makes a new problem as handweeding is costly. Chemical weeding if successful would be a logical solution to the problem.

Growers using tomato transplants also have a weed problem. The problem is primarily in the crop row as weed control between the rows can be controlled with a cultivator. Where weeds are present they interfere with picking and reduce yields. In weedy fields disease and insects are more prevalent. Again the answer to the problem may be chemical weeding. These experiments are a continuation of work started a few years ago.

Procedure

For the direct seeded tomatoes the seedbed was prepared, the pre-planting treatments applied and incorporated and the tomatoes seeded May 22. The pre-planting treatments were applied as a spray and incorporated in the soil with a rototiller set shallow. The seed of the variety Fireball had been germinated prior to planting. Both pre- and post-emergence applications followed seeding. Individual plots were 29 feet long and 3 feet wide. Treatments were randomized in each of 8 blocks. Chemicals were applied in a 2 feet band over the row.

For the transplanted tomatoes the seedbed was prepared and the pre-planting treatments applied and incorporated June 3. Transplanting was started June 3 and completed June 6. Post-planting treatments were applied from 4 to 22 days after transplanting. The variety grown was Campbell 146. Individual plots were 32 feet long and 6 feet wide each having 15 plants. Treatments were randomized in each of 6 blocks. The growing season was dry and no irrigation was applied.

Cultivation controlled the weeds between the rows. An estimate of weed control was made on the direct seeded tomatoes August 12 and on the transplanted tomatoes July 9. A rating of 1 to 10 was used, 1 being most desirable and 10 least desirable. One harvest was made on the direct seeded tomatoes and two harvests on the transplanted tomatoes.

Results

The results in the direct seeded tomato are presented in Table 1. Taking into consideration weed control, plant stand and yield only diphenamid

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was outstanding. Yields from the diphenamid plots averaged over ten tons per acre, the untreated plot produced less than 2 tons and the best of the other plots was less than 5 tons. It is possible that pre-germination of seed prior to planting resulted in a decreased stand of plants with some herbicides, especially those applied prior to planting and incorporated in the soil.

The results in the transplanted tomatoes is presented in Table 2. Taking into consideration weed control, stand of plants and yield the best of the soil incorporation treatments prior to planting was trifluralin applied at 1 pound per acre. On the same basis the best of the post-planting treatments were TD 480 applied at 6 and 9 lbs per acre 4 days after transplanting, amiben G at 6 and 9 lbs. per acre applied 22 days after transplanting and diphenamid alone or in combination with other herbicide.

Conclusion

In the direct seeded tomatoes diphenamid looks very promising for the weeding of this crop when applied at the rate of 6 lbs. per acre the day following planting.

In the transplanted tomatoes a number of chemicals offer promise of weed control and normal yield. As pre-planting soil-incorporation application trifluralin looks good. As post-planting application, TD 480, amiben G and diphenamid look promising.

Table 1. Weed Control, Stand of Plants and Weight of Fruit of Direct Seeded Tomatoes under Chemical Herbicide Treatments

Treatment	Active Rate per Acre lbs.	Application Days from Planting		AVERAGE PER PLOT		
				*Weed Control (1-10)	Stand of Plants	Wt. Mkt. Fruit Tons
1 Nothing	--	--	--	10.0	9.4	1.3
2 PEBC (Tillam)	6	Inc.	- 0	3.5	5.1	1.3
3 R1870	6	"	- 0	4.3	.4	.1
4 Trifluralin	1	"	- 0	3.0	3.0	1.2
5 "	2	Pre-emerg	+ 1	5.1	14.4	4.6
6 CDEC	10	"	+ 1	7.9	16.1	4.1
7 CLEC + CDA	3 + 3	"	+ 1	7.4	13.1	4.0
8 SD 6623	10	"	+ 2	8.1	8.9	2.5
9 Diphenamid (Lilly)	6	"	+ 1	2.6	13.5	10.3
10 " (Upjohn)	6	"	+ 1	4.6	15.5	10.5
11 " (L) + Dinoben G	3 + 3	Pre + 1 + Post	+22	2.0	10.6	3.2
12 " + " (liquid)	3 + 3	" " "	+21	3.9	12.4	4.0
13 Dinoben G	6	Pre (Delay)	+ 7	1.8	1.8	.8
14 " liquid	6	"	+ 7	4.0	7.0	2.4
15 Solan	4	"	+ 7	8.4	15.0	4.1
16 R1870	6	"	+ 7	9.1	7.4	1.1
17 KOCN + TCA	16 + 3	"	+ 7	8.4	11.4	3.1
18 Amiben G	6	Post	+22	3.3	6.9	1.6
19 Diphenamid (Lilly)	6	"	+20	8.3	13.3	2.4
20 Trifluralin	2	"	+20	9.1	9.0	2.1
21 R1607 G	6	"	+22	4.3	2.6	.4
22 IMPA (Zytron)	10	"	+20	9.3	7.3	.8
23 TD 480	4 & 4	Pre (Delay)+ 7	+20	5.0	6.9	1.3
24 TD 482	4 & 4	"	+20	8.4	8.1	1.1
Least significant difference 5%				2.0	5.1	1.0
1%				2.7	6.8	2.3

*Weed control 1-10: 1 Perfect Weed Control
10 Full Weed Growth

Table 2. Weed Control, Stand of Plants and Yield of Fruit of Transplanted Tomatoes under Chemical Herbicide Treatments

Treatment	Active Rate per Acre lbs.	Application Days from Planting	AVERAGE PER PLOT			
			*Weed Control (1-10)	Stand of Plants	Yield Tons/A	
					Early	Second
1 Nothing	--	--	10.0	15.0	1.9	24.8
2 PEBC (Tillam)	4	Soil Inc. 0	4.0	15.0	2.4	26.0
3 " "	6	" 0	5.0	15.0	2.1	29.5
4 R1607 10 G	6	" 0	1.0	15.0	1.5	14.4
5 " "	9	" 0	1.0	14.0	1.5	16.4
6 Trifluralin	1	" 0	2.0	15.0	1.8	30.0
7 " "	1 1/2	" 0	1.3	15.0	1.7	26.5
8 " "	3	Post + 4	4.0	15.0	1.2	27.2
9 " "	4 1/2	" + 4	2.0	15.0	1.1	23.9
10 " "	3 + 3	Post + 1 Post +22	3.2	15.0	.8	29.2
11 Diphenamid (Lilly)	6	Post + 4	2.8	15.0	7.0	30.8
12 " "	9	" + 4	4.0	12.8	2.0	31.0
13 " (Upjohn)	6	" + 4	2.6	15.0	2.0	27.9
14 " "	9	" + 4	1.8	15.0	1.6	34.1
15 Swep	6	" + 4	4.5	12.0	.1	13.7
16 " "	9	" + 4	3.5	7.2	.0	12.3
17 TD 480	6	" + 4	2.5	15.0	.7	26.1
18 " "	9	" + 4	1.5	15.0	.5	36.9
19 Diphenamid (Lilly) + Solan	4 + 4	Post + 4 Post +22	1.9	15.0	1.3	32.5
20 " " + Dinoben G	4 + 4	" + 4 " +22	1.5	15.0	2.2	20.9
21 " " + Amiben G	4 + 4	" + 4 " +22	1.3	15.0	2.4	32.1
22 Amiben G	6	Post +22	3.9	15.0	2.11	28.8
23 " "	9	" +22	5.0	15.0	1.9	28.6
24 Dinoben G	6	" +22	8.0	15.0	2.1	17.4
25 " "	9	" +22	7.8	15.0	2.1	21.3
26 Dinoben liquid	6	" +22	7.2	15.0	1.5	32.5
27 " "	9	" +22	6.8	15.0	1.3	22.9
28 Solan	6	" +22	5.9	15.0	1.1	32.3
29 " "	9	" +22	2.3	14.8	.8	26.6
30 Solan + Solan	4 + 4	Post + 9 Post +22	1.3	13.8	.6	26.6
31 Solan + Paraquat	4 + 1	Post + 9	3.0	3.3	.0	5.7
32 Solan + DCPA	4 + 8	" + 9	1.5	15.0	1.5	27.0
33 DCPA (Dacthal)	8 + 8	Post + 4 Post +22	5.9	14.5	.9	20.2
Least significant difference 5%			2.1	1.7	.5	9.6
			1%	3.0	2.3	12.7

*Weed Control (1-10): 1 Perfect Weed Control; 10 Full Weed Growth.

A Simple Method for Evaluating Longevity of Herbicide Activity
in the Field^{1/}

D. W. Davis^{2/}, J. C. Cialone^{3/} and R. D. Sweet^{4/}

The length of time an herbicide will remain active in the soil is an important factor to be considered in evaluating the potential usefulness of the compound. When more than one cash crop is to be grown on a given field the same season, such as is often the case with vegetables, only those herbicides with a short period of residual activity are safe. On the other hand, where the same crop occupies the land for several seasons such as with corn and certain forages, those chemicals with a long period of residual activity may have definite advantages. In certain instances it is desirable to grow cover crops or soil-improving crops between the cash crops. In these situations the herbicide must be dissipated by time of planting the cover crop or the chemical must be safe on the particular cover crop being grown.

With most newer herbicides, duration of residual activity is not investigated until they are well along in development and in some instances this factor has been inadequately studied until after modest marketing has begun. Although this aspect of every commercially important family of herbicides has been investigated in some detail, the studies have been particularly concerned with pathways of disappearance and the factors influencing them. Of necessity, such studies have had to be quite detailed in nature and, consequently, often prove to be quite time consuming and costly.

The purpose of this paper is to report a simple but effective procedure for estimating the probable duration of residual activity of newer herbicides early in their development, and to present a few illustrative data obtained in 1963 by using this procedure.

Methods

In these studies field plots were utilized which had already been established to evaluate the performance of new compounds on crops and weeds. Chemicals had been applied both pre and post-emergence by means of a small-plot logarithmic sprayer at two locations in the vicinity of Ithaca. Individual plots were 5 feet wide and 60 feet long and consisted of 26 newer chemicals plus appropriate standards with two replications. One location has a fine sandy loam soil, the other a gravelly loam soil. Both have a pH of about 6.0 but the lighter soil has an organic matter level of about 1.5 percent and the other about 5.0 percent.

The chemicals used were: Amchem ACP62-177A; American Cyanamid Ac-101, AC-201, and AC-301; B.A.S.F. HS-119 (Pyramin), and H-119-1; Geary C-1983 and C-2059; Monsanto CP-522, CP-18907, CP-31393, CP-31675, CP-32179, CP-42718, CP-43659, and CP-44176; Shell SD-7961; Stauffer N-3446, R-3552, and R-4518; Union Carbide UC-22463; dicryl, paraquat, Tok, Tordon and trifluralin. In addition to these, the following standard herbicides were used for comparison: NPA (Alanap-3), Chloro IPC, CDA (Randox), and CDEC (Vegadex).

^{1/}Paper No. 507 of the Department of Vegetable Crops, Cornell University, Ithaca, N.Y.

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Normally, plots for preliminary evaluation are allowed to remain undisturbed for much of the growing season and data are obtained from time to time on crop and weed growth. When a new crop of weeds begins to emerge, a given chemical is said to have "broken" and is no longer effective. However, in certain instances if soil environmental conditions had been changed, i.e. by disking and watering, weed emergence might have occurred much earlier. For example, a pre-emergence application of dinitro often gives apparent weed control for four to six weeks, but its actual residual activity is rarely more than four to six days. The present methods were designed to show true rather than apparent residual activity.

Although the initial chemical applications were made earlier on the sandy soil than on the loam soil, and the post-emergence treatments were about four weeks later than the pre-emergence treatments at a given location, the re-working and re-planting schedule was designed to give approximately the same lapse of time between treating and re-working for all plots. About two months following chemical application, after obtaining data on crop and weed responses, the first disking and reseeding treatments were made. Care was taken to disk the plots lengthwise to minimize soil transfer to adjacent plots. On approximately one-half the entire experimental area, beets, broccoli, and cucumbers were seeded in rows and ryegrass broadcast as indicator crops. On the rest of the area only a broadcast seeding of ryegrass was used as an indicator.

One month later, a total of about three months following the herbicide application, after noting crop responses, all experimental areas were again disked and seeded to ryegrass. Several weeks following this seeding, these few plots or portions of plots showing considerable herbicide activity were cultivated by hand and again reseeded. Ryegrass was seeded broadcast, and lettuce and spinach were seeded in rows.

Results and Discussion

Considerable information was obtained on the residual activity, if any, of all the chemicals under study. A few chemicals showed no activity at the first replanting and by the time of the third replanting, the majority had lost all residual activity. The results with eleven compounds exhibiting different patterns of persistence are presented in table 1. No persistence beyond the first replanting was found with any of the following materials: ACP62-177A, CP-18907, CP-31393, CP-32179, CP-42718, CP-43659, CP-44176, N-3446, R-3552, UC-22463, dicryl, paraquat, Tok, NPA, and Chloro IPC. Persistence in the third replanting was slight but detectable with AC-101, AC-201, AC-301, and C-1983.

From table 1, it can be seen that even with most of the more persistent herbicides, residual activity was lessening as the season progressed. It should be noted, however, that Tordon showed no apparent reduction in activity between the third and fourth months.

Data in table 1 are not intended to be fixed values for rates, but rather to be indicative of relative persistence. Obviously, seasonal soil and environmental conditions will greatly influence specific values.

These studies show the need for further work to determine when the more persistent materials finally become inactive. Also there is need to investigate

whether repeated applications will tend to cause more of a problem than single applications.

Table 1. The minimum dosage (lbs/A.) at which severe symptoms occurred initially and at two, three and four months after herbicide application.

Chemical	Initial activity		Two months		Three months		Four months	
	Broad leaves	Grass	Broad Leaves	Grass	Broad leaves	Grass	Broad leaves	Grass
HS-119	3	-	6	6	12	12	No activity	
H-119-1	2	-	6	6	12	12	No activity	
Tordon ^a	<.1875	-	.75	1.5	1.5	1.5	1.5	1.5
(Fine sandy loam)								
CP-522	1.5	-	4	4	12	15	No activity	
(Fine sandy loam)								
(Gravelly loam)	<1.5	-	3	4	6	12	15	15
CP-31675	1.5	-	3	1.5	6	4	8	6
R-4518	1.5	-	8	8	12	12	15	15
(Fine sandy loam)								
(Gravelly loam)	12	-	15	12	20	18	No activity	
SD-7961	1.5	-	3	3	10	6	12	12
C-2059	1½	-	3	3	6	6	8	8
(Gravelly loam)								
CDAAs								
(Randex)	2	-	No activity		No activity		No activity	
CDEC								
(Vegadex)	2	-	No activity		No activity		No activity	
trifluralin	1.5	-	activity		5	activity	6	activity 8

^a/ Application rate was 3 lbs/A down to .1875 lbs/A. All other compounds were applied from 24 lbs/A down to 1.5 lbs/A.

It is hoped that weed research workers will follow the above procedures at least in a modified way in order that more information on persistence will be available at an early date with new herbicides.

Preliminary Field Evaluation of Carbamates on Horticultural Crops^{1/}Dorothy Ann White and J. D. Riggleman^{2/}

Herbicides of the carbamate group often respond in a similar manner if method of application is similar. Incorporation generally improves the efficiency of these herbicides. If applied to a dry, powdery soil incorporation is of less benefit. A moisture seal after surface application often improves weed control. The exponential sprayer (1) and gradient distributor for granular materials (2) were used to study the effect of these herbicides on several horticultural crops, weed species and cover crops.

Materials and Methods

The studies were conducted at the University of Maryland Vegetable Research Farm, Salisbury. The soil is a well-drained loamy sand. The season, though having several periods of heavy rain, was unusually dry. KC 146 tomato transplants and Nemagold sweet potato sprouts were planted May 6 in 64 inch beds 110 feet long and then inter-seeded with Gallatin 50 or Tendercrop snap beans, Pocomoke tomatoes, Harvast Queen cantaloupes, crabgrass, pigweed and German foxtail millet. The first 10 feet of the plot were untreated. Following the untreated area the exponential sprayer was used starting at 16 lbs AI/A and exponentially decreasing for 4 half-dosages to 1/16 of the initial rate. The starting rate with the gradient distributor varied, due to the differences in concentration, density and fineness of the granular materials. Herbicides were applied pre-planting with soil incorporation; within 24 hours after planting; within 24 hours after planting followed by $\frac{1}{2}$ inch of irrigation; within 24 hours after planting as a granular material; and 4 weeks after planting. Plots were evaluated 2 or 3 times. The plots were disced in mid-July and then seeded to oats on July 22. Injury to the oats was recorded August 16. The field was plowed September 2 and drilled to rye September 10. The injury to rye was recorded October 31.

Results and Discussion

The data are presented in Table 1. Of the recently introduced carbamates, several appear promising for weed control in horticultural crops for periods of 8 weeks or more.

Snap beans. R 4461 at 16 lbs AI/A applied to the soil surface caused no injury to the beans. Excellent control of weeds was obtained at 10 lbs AI/A. Whether or not incorporated, R 1910 or R 4572 at 16 lbs AI/A were tolerated by the crop. Incorporation of 5 lbs or surface application of 8 lbs AI/A were necessary for complete weed control.

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Transplanted tomatoes. Tomatoes tolerated 16 lbs AI/A of R 4461 whereas only 10 lbs AI/A were necessary for weed control. R 4572 incorporated at 12 lbs AI/A, applied to the surface at 14 lbs AI/A or applied as a granular at 19 lbs AI/A caused no apparent injury to the tomatoes. Control was obtained with 5, 8 and 10 lbs AI/A respectively.

Direct seeded tomatoes. R 4572 incorporated at 10 lbs AI/A or applied to the surface at 14 lbs AI/A caused no apparent injury to the tomatoes. There was excellent control from 5 or 8 lbs AI/A respectively. R 4461 applied to the surface at 16 lbs AI/A caused no injury to the tomatoes while weed control was excellent at 10 lbs AI/A.

Sweet potatoes. Sweet potatoes tolerated 16 lbs AI/A of R 4572 incorporated or applied to the surface and 19 lbs AI/A from the granular formulation. Weed control was excellent from 5, 8 or 10 lbs AI/A respectively. R 4461 caused no injury at 16 lbs AI/A while 10 lbs AI/A were necessary for weed control.

Cantaloupes. No injury was observed where 12 lbs AI/A of R 1910 were incorporated; 1 lb AI/A was necessary for grass control and 6 lbs AI/A for broadleaved weed control. R 4572 at 14 lbs AI/A from the granular formulation caused no injury. Control was effective from 10 lbs AI/A.

Oats. Of the recently introduced carbamates only R 1910 caused injury to oats. Both stunting and stand reduction occurred above 10 lbs AI/A.

Rye. There was no injury to the rye cover crop from any of the carbamates tested.

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- (1) Dedolph, R. R., C. W. Basham and F. C. Stark. 1960. An exponential sprayer for experimental work. Proc. Amer. Soc. Hort. Sci. 75:785-88.
 - (2) Riggleman, J. D., G. J. Burkhardt and F. C. Stark. 1963. A gradient distributor for the application of granular materials. Proc. North-eastern Weed Control Conference, Jan. 1963.

Table 1. Effects of herbicides applied with an exponential sprayer and gradient distributor to several horticultural crops^{1/}, cover crops^{2/} and weed species^{3/}.

Treatments ^{4/}	Obsv Date	Beans		T. Tom		S. Tom		S. Pot		Canta		Miller		Crab		Pigw		Native		Oats	Ry	
		A	B	A	B	A	B	A	B	A	B	C	D	C	D	C	D	G Bl	8/16	10/		
CDEC inc PF	4E	5/30	-	-	16	10	14	10	16	8	3	2	5	5	5	5	2	2	1	1	16	1
		6/25	-	-	16	6	14	10	16	11	S	S	2	2	5	5	2	2	16	4		
		7/10	-	-	16	16	14	3	16	11	2	S	10	5	7	7	2	2	16	16		
AP	4E	6/4	16	13	16	10	16	10	16	10	16	10	NC	NC	NC	NC	NC	NC	8	8	16	1
		6/25	16	14	16	10	14	14	16	8	16	16	NC	NC	NC	NC	NC	NC	8	8		
		7/12	16	16	16	16	16	16	16	8	16	16	NC	NC	NC	NC	NC	NC	16	16		
AP + irr	4E	6/4	16	10	16	6	16	6	16	10	4	2	NC	NC	6	4	6	4	4	4	16	1
		6/26	16	13	16	16	16	6	16	10	4	2	NC	NC	NC	6	10	6	4	4		
		7/11	16	5	16	16	16	6	16	4	4	2	NC	NC	NC	6	9	6	11	6		
4 wks	4E	6/26	16	16	16	16	16	10	16	16	6	S	NC	NC	NC	NC	NC	NC	NC	NC	16	
		7/10	16	14	16	15	16	10	15	15	4	S	NC	NC	NC	NC	NC	NC	NC	NC		
(15/30) AP (36)	20G	6/4	36	29	36	36	36	36	36	19	11	S	NC	NC	36	19	11	7			36	
		6/26	36	36	36	29	36	30	36	36	S	S	NC	NC	36	28	36	28	36	36		
		7/10	36	36	36	29	36	25	36	19	S	S	NC	NC	NC	36	NC	36	NC	NC		
(24/48) AP (24)	20G	6/4	24	24	24	20	24	7	24	24	24	20	NC	NC	NC	24	10	7	NC	NC	24	
		6/26	24	24	24	24	24	24	24	24	24	24	NC	NC	NC	NC	NC	NC	NC	NC		
		7/10	24	24	24	24	24	8	24	24	24	24	NC	NC	22	22	7	7	10	NC		
(30/60) AP (26)	20G	6/4	26	26	26	21	26	8	26	26	26	21	NC	NC	-	-	-	-	-	-	26	
		6/26	26	26	26	26	26	26	26	26	26	21	NC	NC	-	-	-	-	-	-		
		7/10	26	26	26	26	26	26	26	26	26	21	NC	NC	-	-	-	-	-	-		
CIPC AP	4E	6/4	16	5	10	5	S	S	16	6	16	6	10	3	-	-	-	-	1	1	16	
		6/25	14	6	16	S	S	S	16	5	S	S	3	2	-	-	-	-	16	1		
		7/12	14	14	16	6	S	S	16	10	S	S	3	2	-	-	-	-	16	1		

Table 1 (Cont.)

Treatments ^{4/}	Obsv Date	Beans ^{5/} A ^{5/} /B ^{6/}	T.Tom A B	S.Tom A B	S.Pot A B	Canta A B	Millet C ^{7/} /D ^{8/}	Crab C D	Pigw C D	Native G Bl	Oats 8/16	Ry 10/	
AP + irr	4E	6/4	16 5	16 6	4 4	16 4	10 1	4 4	4 4	5 4	4 12	16	1
		6/26	16 11	16 6	5 4	16 5	S S	4 4	4 4	NC 16	6 16		
		7/11	16 16	16 6	11 4	16 4	2 S	4 4	NC 16	NC 16	16 16		
AP (8)	5G	6/4	8 4	8 2	2 1	8 6	8 S	NC 8	- -	- -	- -	8	
		6/26	8 4	8 2	2 1	8 2	2 1	3 3	- -	- -	NC NC		
		7/10	8 8	6 2	6 6	8 8	2 2	5 3	- -	- -	NC NC		
EPTC inc PP	6E	5/30	10 8	S S	1 S	16 6	4 S	1	1	1	1 1	16	1
		6/25	10 8	5 S	1 S	16 1	S S	1	1	1	4 1		
		7/10	10 8	6 4	2 S	16 5	S S	1	1	1	2 2		
AP	6E	6/4	16 6	10 2	4 S	16 10	4 S	2 1	- -	- -	1 1	16	1
		6/25	16 16	9 2	4 S	16 13	5 S	1	- -	- -	1 3		
		7/12	16 16	15 4	4 S	16 16	6 S	1	- -	- -	2 5		
4 wks	6E	6/26	16 16	16 4	16 4	16 6	16 4	NC NC	- -	- -	NC NC	10	1
		7/10	16 16	16 S	16 4	16 S	16 5	NC NC	- -	- -	NC NC		
R 1607 inc PP	6E	5/30	11 5	16 6	4 3	11 6	6 2	1	1	1	1 1	12	1
		6/25	14 2	16 3	3 1	16 4	5 S	1	1	1	2 1		
		7/10	15 4	16 3	3 2	16 10	5 2	1	1	1	1 1		
AP	6E	6/4	16 10	16 8	4 S	16 10	4 S	10 6	1	1	1 1	16	1
		6/25	16 16	16 3	5 S	16 6	4 S	6 3	1	1	1 1		
		7/12	16 16	16 10	5 2	16 16	4 S	5 2	1	1	1 1		
AP + irr	6E	6/4	1 S	4 2	2 S	16 6	1 S	1	- -	- -	1 1	16	1
		6/26	2 S	6 4	2 S	16 5	3 S	1	- -	- -	1 1		
		7/11	2 S	10 5	S S	16 16	3 3	1	- -	- -	1 1		
4 wks	6E	6/26	4 S	16 10	16 16	16 16	5 S	NC NC	- -	- -	NC NC	15	1
		7/10	3 S	16 16	16 16	16 16	5 S	NC NC	- -	- -	NC NC		
AP (17)	10G	6/4	3 2	17 17	5 2	17 17	6 4	6 5	- -	- -	3 3	17	1
		6/26	3 S	17 9	4 2	17 17	8 5	8 5	- -	- -	5 5		
		7/10	2 2	17 9	6 3	17 17	17 17	7 4	- -	- -	6 6		

Table 1 (Cont.)

Treatments ^{4/}		Obsv Date	Beans A ^{5/} B ^{6/}	T.Tom A B	S.Tom A B	S.Pot A B	Canta A B	Millet C ^{2/} D ^{3/}	Crab C D	Pigw C D	Native G B1	Oats 8/16	Rye 10/3
R 1870 inc PP	6E	5/30	16 6	16 10	8 5	16 8	8 6	1	1	1	1 1	6	1
		6/25	6 4	10 5	5 2	16 11	6 8	1	1	1	2 6		
		7/10	6 3	10 5	5 2	16 11	6 8	1	2 2	1	4 6		
AP	6E	6/4	16 16	16 10	6 2	16 8	16 6	NC 16	3 2	8 5	1 1	16	1
		6/25	16 16	16 16	6 8	16 4	16 5	NC NC	4 2	4 2	1 1		
		7/12	16 16	16 16	6 8	16 8	16 4	NC NC	2 2	2 2	1 1		
R 1910 inc PP	6E	5/30	14 6	4 1	2 1	16 4	16 11	1	1	1	1 4	6	1
		6/25	14 4	4 8	8 8	5 8	16 4	1	1	1	1 6		
		7/10	14 14	4 8	8 8	4 8	14 4	1	1	1	3 10		
AP	6E	6/4	16 16	10 4	8 8	16 8	16 4	13 10	- -	- -	1 1	16	1
		6/25	16 16	10 4	8 8	16 6	16 4	8 6	- -	- -	8 8		
		7/12	16 16	10 2	8 8	16 10	16 8	8 6	- -	- -	16 16		
R 2061 inc PP	6E	5/30	16 16	16 16	6 5	16 10	6 4	4 4	2 2	2 2	1 1	16	1
		6/25	16 5	16 4	9 7	16 10	8 8	1	4 3	1	5 5		
		7/10	16 14	16 7	9 7	16 16	8 8	3 1	1	1	1 1		
AP	6E	6/4	16 13	16 10	16 4	16 11	13 6	16 6	- -	- -	1 1	16	1
		6/25	16 16	16 16	16 10	16 16	16 2	10 10	- -	- -	1 1		
		7/12	16 16	16 16	16 16	16 16	16 6	10 10	- -	- -	1 1		
AP + irr	6E	6/4	16 10	16 6	2 8	16 16	2 8	3 2	1	1	1 1	16	1
		6/26	16 10	16 10	4 1	16 16	4 2	3 2	1	1	3 3		
		7/11	16 10	16 2	4 8	16 16	4 2	3 2	1	1	4 4		
4 wks	6E	6/26	16 8	16 8	6 4	16 16	10 4	NC NC	NC NC	NC NC	NC NC	16	1
		7/10	16 16	16 16	4 8	16 16	14 4	NC NC	NC NC	6 6	NC NC		
AP (18)	10G	6/4	18 6	18 15	18 6	18 15	18 11	15 10	- -	- -	2 2	18	1
		6/26	18 9	18 18	9 7	18 18	18 18	15 10	- -	- -	3 3		
		7/10	18 7	18 18	15 7	18 18	18 18	14 10	- -	- -	6 6		

Table 1 (Cont.)

Treatments ^{4/}		Obsv Date	Beans A ^{5/} /R ^{6/}	T.Tom A B	S.Tom A B	S.Pot A B	Canta A B	Millet C ^{7/} /D ^{8/}	Crab C D	Pigw C D	Native G B1	Oats 8/16
R 4572 inc PP	6E	5/30	16 16	16 3	16 16	16 10	4 4	1	1	1	1 1	16
		6/25	16 16	16 8	16 2	16 11	S S	1	1	1	13 1	
		7/10	16 16	16 16	16 15	16 15	S S	1	1	1	8 1	
AP	6E	6/4	16 13	16 8	16 2	16 10	5 1	8 6	- -	- -	1 1	16
		6/25	16 16	16 16	16 6	16 13	6 3	8 6	- -	- -	6 4	
		7/12	16 16	16 16	16 3	16 16	6 5	10 4	- -	- -	8 6	
AP + irr	6E	6/4	16 6	16 4	13 S	16 16	S S	1	1	1	1 1	16
		6/26	16 16	16 6	16 2	16 16	1 S	2 1	1	4 1	1 2	
		7/11	16 16	16 10	16 2	16 16	2 2	1	1	6 1	2 2	
4 wks	6E	6/26	16 16	16 16	16 16	16 16	6 4	NC NC	NC NC	NC NC	NC NC	16
		7/10	16 16	16 16	16 16	16 16	4 2	NC NC	NC NC	NC NC	NC NC	
AP (19)	10G	6/4	19 10	19 3	6 2	19 9	12 6	19 14	- -	- -	2 2	19
		6/26	19 19	19 15	15 S	19 16	14 5	19 10	- -	- -	5 5	
		7/10	19 19	19 19	19 6	19 19	18 18	19 9	- -	- -	8 8	

- 1/ Planted 5/6: snap beans (Beans), transplanted tomatoes (T.Tom), direct seeded tomatoes (S.Tom), sweet potatoes (S.Pot) and cantaloupes (Canta).
- 2/ Oats planted 7/22; injury noted 8/16. Rye planted 9/10; injury noted 10/31. Data expressed as the highest rate (lbs AI/A) at which no injury was observed.
- 3/ German foxtail millet (Millet), crabgrass (Crab) and pigweed (Pigw) seeded 5/6. Control of (native) weeds was observed: grasses (G) (crabgrass, goosegrass and lovegrass); broadleaved weeds (B1) (pigweed lambsquarters, carpetweed and henbit).
- 4/ Herbicides incorporated within 12 hrs before planting (inc PP); surface-applied within 24 hrs after planting (AP); or surface-applied 4 wks after planting (4 wks). One set of AP plots was irrigated within 1 hour after herbicide application (AP + irr). The highest rate of application was 16 lbs AI/A unless noted i
- 5/ A) The highest rate in lbs AI/A at which the crop remained alive.
- 6/ B) The rate in lbs AI/A at which the crop showed no visible injury. "S" indicates sensitivity at low rate applied.
- 7/ C) Rate in lbs AI/A necessary for 100% control. "NC" indicates no control at the highest rate applied (-) indicates seeded species did not emerge even in the untreated area as a result of improper seeding depth.
- 8/ D) Rate in lbs AI/A necessary for 90% control.

The Influence of Sheet Plastic and Petroleum Mulch on Crop
and Weed Responses to Herbicides^{1/}

J. C. Ojalone^{2/}, W. H. Gutenmann^{3/}, D. J. Lisk^{4/}, and R. D. Sweet^{5/}.

(Abstract)

In the last few years there has been an interest in mulching materials for horticultural crops, especially sheet plastic and petroleum mulch. As a result, studies were conducted to determine the possible use of mulch-herbicide combinations and to assess some of the factors affecting the performance of herbicides when used with mulches.

I Asphalt

1. Three years work with petroleum mulch indicate that a number of pre-emergence herbicides, including EPTC, CDEC, CDAA, CIPC, 2,4,D and Atrazine, can be used effectively with petroleum mulch. Dacthal performed poorly with petroleum mulch and DN, unless specially formulated, also performed poorly. Certain other herbicides including Alanap and Dymid were found to be intermediate in response when used with petroleum mulch.

2. Soil surface physical condition and soil surface moisture were studied in relation to the activity of Alanap-petroleum mulch combinations. Rolling the soil to give a smooth soil surface slightly reduced weed control obtained with Alanap. Soil surface moisture appeared to have little effect on the activity of Alanap-mulch combinations.

3. Studies with EPTC (E.C.) indicate that when used with petroleum-mulch it is consistently effective regardless of soil moisture.

4. When 2,4,D Ester was applied pre-emergence just prior to petroleum mulch, sweet corn tolerated as much as 12 lbs. to the acre. In addition, excellent broadleaf and grass control was obtained for the entire season with rates as low as 0.75 lbs/acre. Analyses of soil profiles taken six weeks after application, showed negligible amounts (less than .1ppm) of 2,4,D in the soil, however, high amounts (up to 100 ppm) were found in the petroleum mulch film.

II Sheet Plastic (Polyethylene)

1. Preliminary studies with sheet plastics indicate that EPTC, 2,4,D, Lorox, Tillam and DN performed as well when applied pre-emergence under plastic as when applied pre-emergence on soil surface with no sheet plastic covering.

2. Treatments in which the herbicides were applied to the plastic rather than directly to the soil were included in these studies. Lorox, DN and Atrazine gave satisfactory weed control when applied in this manner.

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Incorporation of Trifluralin in Snap Beans, Soybeans and Cantaloupes^{1/}J. D. Riggleman and J. A. Meade^{2/}

Efficacy of a herbicide often depends on the manner in which it is applied. Many of today's sophisticated herbicides require special application to obtain maximum dependability and weed control with a minimum of cost and injury to the crop. In Maryland snap beans and soybeans have been tolerant to trifluralin at rates greater than those necessary for weed control. Cantaloupes have been somewhat intermediate in tolerance to trifluralin. Weed control from trifluralin has been excellent where the herbicide was incorporated, but rather variable where applied to the soil surface. Since irrigation has improved the reliability of the herbicide as well as reduced the amount necessary for weed control, this study was employed to observe the effects of several methods of incorporation compared to surface application and semi-incorporation with irrigation.

Materials and Methods

The experiment was conducted at the University of Maryland Vegetable Research Farm, Salisbury. The soil is a loamy sand, low in organic matter. The plots were irrigated to provide 1 acre-inch of water every 10 days.

A split-plot in 4 replications was used for the plot design. Each plot consisted of a 27 foot row of Hood soybeans, Harvester snap beans, Harvest Queen cantaloupes, millet and a mixture of crabgrass and pigweed. The soil contained a sufficient natural population of goosegrass. The crop rows were planted 26 inches apart, with the rows of weeds seeded between the crop rows. The plots were established July 29. Only the snap beans were harvested, on September 19 and 30. The snap bean yields were adjusted to 36 inch rows.

Trifluralin was sprayed on a dry soil surface within 4 hours after planting at rates of $\frac{1}{2}$, 2 and 4 lbs AI/A with no further treatment. Trifluralin at $\frac{1}{2}$ lb AI/A was sprayed on a dry soil surface and incorporated to a depth of 4 inches by rototilling^{3/} immediately or 21 hours after herbicide application. The weather after herbicide application was sunny with a maximum temperature of 92° for the first 4 $\frac{1}{2}$ hours. This was followed by increasing cloudiness with a few sprinkles just before dark. Minimum night temperature was 78° followed by cloudiness until incorporation the following morning. Incorporation of $\frac{1}{2}$ lb AI/A of the herbicide was also effected by discing once with a tandem disc or by discing twice with a tandem disc immediately after herbicide application. Trifluralin at $\frac{1}{2}$ lb AI/A was applied to a dry soil surface and followed with $\frac{1}{2}$ inch of irrigation. Trifluralin at $\frac{1}{2}$ lb AI/A was applied to soil that had

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- ^{3/} Tractor mounted, PTO operated-Ferguson Rotovator, made by Ferguson Manufacturing Co., Suffolk, Virginia

received $\frac{1}{2}$ inch of irrigation. Discd, rototilled and irrigated checks received no herbicides. An 18 foot portion of the discd check was hand weeded after initial weeds reached a height of 3-4 inches and was then kept free of weeds by hoeing. Plots were rated for injury to the crops and weed control on August 20 and September 10.

Results and Discussion

The data are presented in Table 1.

Trifluralin without incorporation. Cantaloupes showed moderate injury from surface application of trifluralin at $\frac{1}{2}$, 2 and 4 lbs AI/A. In contrast snap beans or soybeans were relatively free from injury. Weed control was nearly perfect from the 2 and 4 lbs AI/A rates of trifluralin and good from $\frac{1}{2}$ lb AI/A. Snap bean yields were unaffected by the herbicide applied to a dry soil.

Trifluralin incorporated with a rototiller. Trifluralin at $\frac{1}{2}$ lb AI/A incorporated with a rototiller immediately after application caused severe injury to cantaloupes and moderate injury to soybeans. There was only slight injury to snap beans with no reduction in yield. Weed control was perfect from this treatment. When incorporation was delayed 21 hours, cantaloupes, snap beans and soybeans were only slightly injured. Weed control was good but not as complete as it was where trifluralin was incorporated immediately after application.

Trifluralin incorporated with a tandem disc. Incorporation by single or double tandem discing showed very little difference over incorporation by rototilling except that cantaloupes were less injured by the former.

Trifluralin with irrigation before or after application. Where $\frac{1}{2}$ lb AI/A of trifluralin was followed with $\frac{1}{2}$ acre-inch of water, there was more injury to cantaloupes than where the irrigation preceeded the herbicide. Snap beans and soybeans were not injured by either treatment. Weed control was good where irrigation followed trifluralin application and acceptable where the herbicide was applied to a wet soil. The snap bean yield was unaffected by either treatment.

Summary and Conclusions

The efficacy of mid-season applications of trifluralin is only slightly affected by method of application at the rates studied in this experiment. Cantaloupes were slightly to moderately injured by all treatments of trifluralin except where it was applied to a wet surface. Snap beans were not injured by any treatment of trifluralin. Soybeans were injured only where trifluralin was incorporated with a rototiller immediately after application.

Weed control was acceptable from $\frac{1}{2}$ lb AI/A applied to a wet or dry surface with no incorporation and good where irrigation followed the herbicide. Nearly perfect weed control was obtained from all other trifluralin treatments.

Table 1. Effect of application method of trifluralin on injury^{1/} to late seeded^{2/} cantaloupes, snap beans and soybeans, on control^{3/} of millet, crabgrass, goosegrass and pigweed, and on the yield of snap beans.

Treatment ^{4/}	Obsv. Date	Canta-loupes	Snap Beans	Soy-beans	Millet	Crab-grass	Goose-grass	Pig-weed	Snap Bean T/A
Disced	8/20	10.0	10.0	10.0	0	0	0	0	1.93 b
Check ^{5/}	9/10	3.0	3.0	3.0	0	0	0	0	
Rototilled	8/20	10.0	10.0	10.0	0	0	0	0	
Check	9/10	3.0	3.0	3.0	0	0	0	0	
4 lbs on dry surface	8/20	10.0	10.0	10.0	10.0	10.0	10.0	10.0	3.49a
	9/10	7.8	9.5	9.0	10.0	10.0	10.0	10.0	
2 lbs on dry surface	8/20	9.5	10.0	10.0	10.0	10.0	10.0	10.0	3.48a
	9/10	8.3	9.3	9.0	10.0	10.0	10.0	10.0	
$\frac{1}{2}$ lb on dry surface	8/20	10.0	10.0	10.0	8.8	10.0	7.8	9.8	2.87ab
	9/10	7.8	8.3	8.5	7.0	9.0	7.3	9.6	
$\frac{1}{2}$ lb on dry sur + roto immed	8/20	5.0	10.0	9.0	10.0	10.0	9.1	10.0	3.38a
	9/10	4.8	8.0	6.5	10.0	10.0	9.1	10.0	
$\frac{1}{2}$ lb on dry sur + roto in 21 hrs	8/20	9.8	10.0	9.8	10.0	8.5	7.6	10.0	3.71a
	9/10	8.5	8.8	8.5	10.0	8.5	6.5	10.0	
$\frac{1}{2}$ lb on dry sur + 1 discing	8/20	10.0	10.0	10.0	10.0	10.0	9.1	10.0	3.09a
	9/10	8.0	8.3	7.8	10.0	10.0	9.3	10.0	
$\frac{1}{2}$ lb on dry sur + 2 discings	8/20	9.3	10.0	10.0	10.0	10.0	9.8	10.0	3.11a
	9/10	7.0	8.3	8.5	10.0	10.0	9.5	10.0	
$\frac{1}{2}$ lb on dry sur + $\frac{1}{2}$ inch irr	8/20	9.3	10.0	9.0	10.0	10.0	8.5	8.8	3.87a
	9/10	7.5	9.5	8.0	9.9	10.0	8.0	8.8	
$\frac{1}{2}$ lb on wet surface	8/20	10.0	10.0	10.0	9.0	10.0	8.1	6.3	3.09a
	9/10	9.3	8.8	8.3	7.4	9.5	7.8	6.0	
irrigated check	8/20	9.3	10.0	8.0	0	0	0	0	
	9/10	3.0	3.0	3.0	0	0	0	0	

1/ Rated 1-10 (10 represents no apparent injury to the foliage).

2/ Crops and weeds seeded July 29.

3/ Rated 1-10 (10 represents nearly perfect control, 7 represents acceptable commercial control and below 7 would be unacceptable).

4/ Check and trifluralin treatments established July 29.

Some Factors Affecting the Residual Activity of Diphenamid^{1/}

• D. W. Davis^{2/}, J. C. Cialone^{3/}, and R. D. Sweet^{4/}

Diphenamid applications for weed control in vegetables have been observed by the authors and several other investigators to adversely affect the establishment of fall cover crops. Only a few of these observations, however, have been recorded in the literature. Le Baron (1963) reported on the use of diphenamid in horticultural crops in 1962 and noted there was a problem of residual activity. Ferrant (1962) observed that 4, 6, and 8 pounds of diphenamid applied in June hurt the fall cover crop.

Eli Lilly Company (1963) reported in their technical data on diphenamid "Susceptible crops seeded in the fall may be damaged from Dymid remaining in the soil. Thorough discing or plowing will reduce or dilute the Dymid so that normal growth may result. Susceptible crops may be planted the year following Dymid treatment with no yield reduction". The Company further states the compound is intermediate in its leaching characteristics, with losses being greater in sandy soils than in clay or loam soils, due to leaching and readily adsorbed on organic soils.

Considering the potential use of diphenamid, these observations and reports stimulated an interest to investigate the longevity of its activity in the soil, and some of the cultural practices which may cause it to decrease.

The purpose of this study was to determine the effect of rate, time of application, moisture, and tillage on the residual activity of diphenamid in the soil.

Methods

One experiment was carried out in 1963 on a gravelly loam soil having moderate internal drainage, pH about 6.0 and organic matter about 4.5 percent. A randomized complete block plot layout was used. Four rates of diphenamid, 0 (check), 1, 3, and 6 lbs./A active as 80W Dymid were applied with a small plot hand operated CO² sprayer on June, 7, July 6, and August 1, 1963. Two replications were irrigated with overhead sprinkler system and two replications were not irrigated. A total of 1.5 inches of irrigation was applied on August 26, 27, and 30. At the end of each period of irrigation the soil appeared to be saturated but percolation was slow. The amount of rainfall from the first chemical application to the time of planting the cover crop was 2.34 inches in June, 3.17 inches in July and 3.18 inches in August. However, only one rain, 1.07 inches on July 7, could be considered substantial. The remainder came as light showers and was quickly lost by rapid evaporation.

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Disking and plowing were the two tillage treatments used and both were done on August 23. Plots were 15 feet square and sufficient space was left between plots so tilling could be done with a tractor and not drag soil from one plot to the next. On September 3, all plots were disked twice then annual ryegrass was seeded and disked in lightly as a typical cover crop.

At the time of seeding, two more treatments of diphenamid were applied in log-plots with rates ranging from 8 down to .5 lbs./A on one plot and from 2 to .125 lbs./A in the other. These were replicated twice. The purpose of these special log plot treatments was to serve as a guide in determining in a quantitative way the amount of active herbicide from the original treatment actually present in the soil at the time of seeding the cover crop.

Ratings of the cover crop were made on October 11, about five weeks after seeding. The system used was a 1 to 9 rating on the ryegrass; 1 indicating no crop and 9 indicating a very good normal crop. At the time of rating there was groundsel (*Senecio vulgaris*) present and notes were made on its growth but the stand was not sufficiently uniform throughout the field to make ratings in all plots.

Results

The cover crop ratings for all treatments are summarized in table 1. All data were statistically analyzed but to shorten the paper the analysis is not presented.

The activity of diphenamid on the cover crop was substantially increased as the rate of application was increased. This relationship held in all phases of the experiment. Rate of chemical was much more important in determining activity on the cover crop than any other factor studied. Regardless of other treatments, no satisfactory cover crop was established when 3 or 6 pounds of diphenamid had been applied.

As the period of time between herbicide treatment and seeding was increased, the residual activity tended to decrease somewhat. This decrease was not substantial but the trend was observed.

Irrigation did not overcome the serious reduction in cover crop growth caused by the 3 and 6 pound rates of diphenamid. There was a significant interaction, however, between rate and irrigation (Figure 1). At rates of 3 and 6 pounds irrigation gave slightly increased cover crop growth whereas at the 0 and 1 pound rate, irrigation slightly decreased cover crop growth.

Tillage also did not overcome serious reduction in cover crop growth caused by the higher rates of diphenamid. There was a significant interaction, however, between rate and tillage (Figure 2). At rates of 3 and 6 pounds, plowing gave slightly increased cover crop growth whereas at the 0 and 1 pound rate, plowing slightly decreased cover crop growth. It is likely this decrease in the plowed check was caused by the very dry season.

The log plots, treated at time of seeding, showed that slightly over 0.5 pounds of diphenamid completely eliminated the ryegrass (Figure 3). This indicates the extreme sensitivity of the ryegrass to diphenamid and helps to

correlate the rating of the cover crop to the amount of herbicide still active in the soil. From this it is suggested the plots treated with 6 lbs./A had slightly less than .25 lbs./A still active in the soil at the time of seeding.

Table 1. Ratings on ryegrass seeded September 3 on plots treated with diphenamid during June, July, and August.

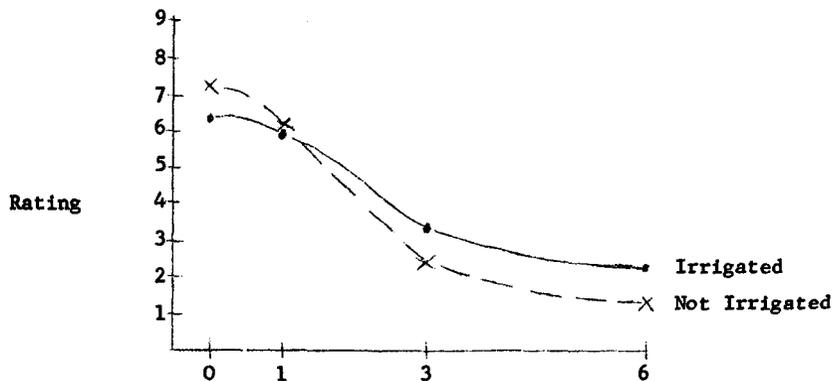
Treatment	lbs/A	Tillage August 23	Ratings ^{1/}	
			Irrigated	Non-Irrigated
<u>Sprayed June 7</u>				
1	0	Disk	6.5	7.5
2	1	"	6.5	7.0
3	3	"	3.0	2.5
4	6	"	2.0	1.0
5	0	Plow	5.0	6.5
6	1	"	6.5	7.0
7	3	"	6.0	4.0
8	6	"	4.0	2.0
<u>Sprayed July 6</u>				
9	0	Disk	6.5	8.0
10	1	"	5.5	5.0
11	3	"	2.0	1.5
12	6	"	1.0	1.0
13	0	Plow	7.0	7.0
14	1	"	6.0	7.5
15	3	"	4.5	3.0
16	6	"	3.5	2.0
<u>Sprayed August 1</u>				
17	0	Disk	7.0	8.0
18	1	"	5.5	5.0
19	3	"	1.5	1.0
20	6	"	1.0	1.0
21	0	Plow	7.0	6.5
22	1	"	7.0	5.5
23	3	"	4.5	3.0
24	6	"	2.5	2.0

^{1/}A rating of 7.0=commercially acceptable; 5=reduced stand and some stunting.
1=no growth.

Summary

These results were based on only one experiment on one soil type. Further testing under different conditions would probably produce some degree of variation in the results. However, no combination of cultural practices served as a means of assuring a good fall cover crop of ryegrass when three or more pounds of diphenamid had been used. With high rates, plowing and irrigation

Fig. 1. Rate x Irrigation



Pounds Per Acre Active Diphenamid

Fig. 2. Rate x Tillage

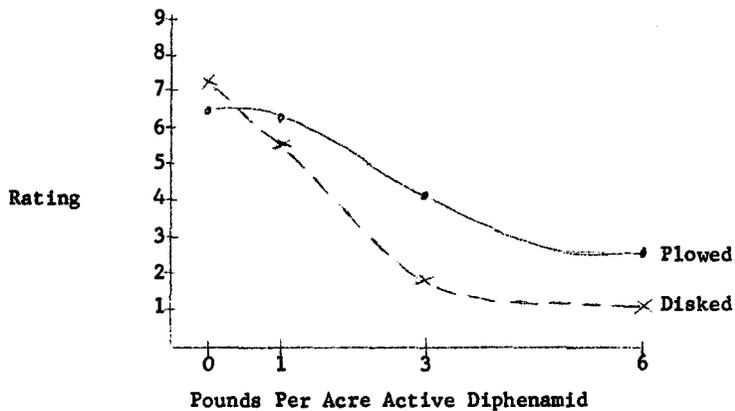
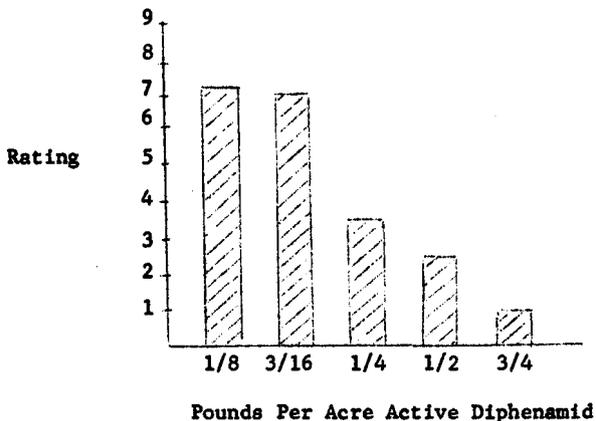


Fig. 3. Ratings of Ryegrass Response to Logarithmic Applications of Diphenamid Made at Planting.



tended to decrease the residual activity of diphenamid in the soil, slightly more than did disking and no irrigation. These practices, however, did not improve the growing conditions sufficiently to make them of value because they did not overcome the severe injury from high rates of application.

Further work is needed to determine the influence of soil types and season on residual activity of diphenamid. Also, studies should be made to determine the principal pathways of disappearance of diphenamid from the soil.

Residue Analysis of Various Fruits and Vegetables Treated
with DCPA, Prometryne and Trifluralin for Weed Control^{1/}

P. B. Manning, T. W. Kerr, C. E. Olney, V. G. Shutak and H. C. Gardner^{2/}

The compounds DCPA (dimethyl 2,3,5,6-tetrachloroterephthalate, prometryne (2,4 bis(isopropylamino)-6-methylmercapto-s-triazine) and trifluralin (a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) are relatively new pre-emergent herbicides advocated for the control of either or both annual grasses and broadleaf weeds in various crops. The investigation reported here was undertaken to determine whether measurable amounts of the three herbicides would accumulate in various fruits and vegetables following application in the field.

PROCEDURE

The vegetables, which included Chantenay Red Cored carrot, Pascal celery transplants, Black Seeded Simpson lettuce, Fordhook lima bean, Long Tendergreen snap bean and Long Standing Bloomsdale spinach, were planted on a very fine sandy loam from early May to early June, according to suitable weather and planting conditions for each crop. Four randomly replicated 25-foot rows, spaced 4 feet apart, for both herbicide and check treatments of each vegetable were provided. The fruits, which were growing in a stony loam, included the peach varieties Golden Jubilee, Hale Haven and Elberta, and the grape varieties Catawba, Concord and Delaware. Three single tree replicates of each peach variety and three vines of each grape variety were used per treatment. Untreated checks containing an equal number of plants were provided.

All three herbicides were applied either as aqueous suspensions or emulsions using a hand-operated, compressed air sprayer at 40 pounds per square inch. The DCPA, a wettable 75% powder, was applied on May 4 at the rate of 8 pounds of active ingredient in 80 gallons of water per acre immediately after seeding the lettuce, carrot and spinach. The trifluralin, a 4 pound per gallon emulsifiable concentrate, was applied at the rate of two pounds of active ingredient per acre in 80 gallons of water to the soil on the same date, and after discing the soil once lightly to a depth of approximately 4 inches, the carrots were planted. The snap beans and celery plants in the trifluralin-treated soil were planted on May 22, and on June 10 the lima beans were planted. The prometryne, an 80% wettable powder, was applied on May 22 at the rate of 4 pounds of active ingredient in 40 gallons of water per acre to the seeded carrots and at 3 pounds per acre to the newly transplanted celery. On June 13, three days after the

^{1/}Contribution #1099 from the Rhode Island Agricultural Experiment Station, supported in part by funds from Regional Research Project NE-36.

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lima beans had been planted, prometryne was applied at 6 pounds of active ingredient per acre. Four and 8 pounds of active ingredient per acre were applied to the uncultivated soil surface under the peach varieties Hale Haven and Elberta, and the grape varieties Concord and Delaware on April 19. Four pounds per acre was applied to the soil under the peach variety Golden Jubilee, and 6 pounds per acre to the grape variety Catawba on the same date.

Harvest of the various vegetables and fruits took place as they matured during the season. Some of the snap beans, lettuce, spinach and celery were washed to remove possible herbicide contaminated soil and some were left unwashed. The carrot tops were removed and the roots washed and scrubbed with a vegetable brush. The lima beans were shelled. The peaches and grapes were not washed before analysis. The representative field sample size from each of 4 replicates of the various vegetables was approximately 1120 grams of carrots, 500 grams of snap beans, 350 grams of shelled lima beans, 350 grams of lettuce and spinach, and 540 grams of celery taken from seven plants. In sampling the peaches 20 fruits were picked from each of the three trees, one-quarter of each fruit taken and the quarters combined and frozen in a polyethylene bag for analysis later. The grapes were handled similarly, except that random bunches totaling approximately 1520 grams were harvested from the three vines in each treatment. In every instance, with both vegetables and fruit, the replicates were combined and the material finely chopped in a food chopper before analytical subsamples were taken. Those materials that were not analyzed immediately after harvest were frozen for analysis later.

The analytical methods were either supplied by the manufacturer of the herbicide, or as in the case of DCPA, were developed in the laboratory. The procedure for determining residues of DCPA has been described by Manning et al (1). In the method, a representative 50 gram sample of vegetable was extracted with acetone and an aliquot of filtered extract partitioned into hexane. The DCPA content of the hexane solution was then measured by electron-capture gas chromatography. A similar procedure, supplied by Eli Lilly and Company(2), was used to determine residues of trifluralin. In this instance a 20 gram sample of vegetable was extracted with hot methanol, and after evaporating the methanol, the residue was taken up in hexane, washed with water and chromatographed on florisil, eluting with hexane. The eluate was then concentrated, made to volume and the trifluralin measured by electron-capture gas chromatography. In the determination of prometryne, a 200 gram sample of fruit or vegetable was tumbled with n-pentane, after which an aliquot of extract was selected, evaporated to dryness and carried through the analytical method supplied by the Geigy Chemical Company (3). The method consists essentially of converting prometryne to hydroxypropazine by acid hydrolysis, and quantitatively measuring the latter spectrophotometrically using the base line technique. In the celery samples it was necessary to treat the sulfuric acid hydrolysate with Darco G-60 in order to reduce interfering substances which absorbed strongly in the 225 millimicron region.

In addition to analyzing the herbicide treated field samples, in every instance untreated fruits and vegetables were fortified with the respective herbicide as a means of comparison.

RESULTS

As indicated in table 1, small amounts of DCPA were found in spinach, lettuce and carrot. In spinach and lettuce there was evidence of diminution in amount of residue as the crop matured. Also, washing the produce tended to reduce the amount of residue found on or in the crop. In carrot there was a slight reduction in the amount of residue found as the roots became larger. Recoveries of DCPA added to the acetone extracts of untreated vegetable samples averaged over 95 per cent.

The results presented in table 2 show that residues of prometryne in carrot, celery, lima bean, three varieties of peaches and three varieties of grapes were less than 0.05 ppm, the limit of sensitivity of the method. Each prometryne treated crop was compared with an untreated check and a check sample fortified with prometryne at the 0.05 ppm level. In all cases the prometryne in the fortified check was detectable.

Residues of trifluralin, shown in table 3, were less than 0.01 ppm in snap bean, lima bean and celery, while carrot was found to contain 0.18 ppm on the first harvest date and 0.13 ppm fifteen days later. Recovery of trifluralin added to carrot at the 0.2 ppm level was 90 per cent, while trifluralin in untreated check samples of other vegetables fortified at the 0.01 ppm level was readily detectable.

Table 1. Residues of DCPA in various vegetables at harvest following application at eight pounds per acre as a pre-emergent treatment. Kingston, R. I., 1963.

Crop	Condition	Date harvested	Residue ppm
Spinach	Unwashed	7/5/63	0.24
"	"	7/18/63	0.06
"	Washed	7/18/63	0.03
Lettuce	Unwashed	7/5/63	0.34
"	"	7/18/63	0.15
"	Washed	7/18/63	0.07
Carrot	Washed	7/22/63	0.39
"	"	8/5/63	0.32

Table 2. Residues of prometryne in various vegetables and fruits following application as a pre-emergent treatment. Kingston, R. I. 1963.

Crop	Condition or variety	Active toxicant	Residue
		lb./A	ppm
Lima bean	Shelled	6	<0.05
Carrot	Washed	4	<0.05
Celery*	Unwashed	3	<0.05
"	Washed	3	<0.05
Peach	Golden Jubilee	4	<0.05
"	Hale Haven	4	<0.05
		8	<0.05
:	Elberta	4	<0.05
		8	<0.05
Grape	Concord	4	<0.05
"		8	<0.05
"	Delaware	4	<0.05
"		8	<0.05
"	Catawba	6	<0.05

*Prometryne applied as a post-transplanting treatment.

Table 3. Residues of trifluralin in various vegetables following application at 2 pounds per acre as a pre-emergent treatment. Kingston, R. I. 1963.

Crop	Condition	Date	Residue
		harvested	ppm
Snap bean	Unwashed	7/15/63	<0.01
"	"	7/22/63	<0.01
"	Washed	7/22/63	<0.01
Carrot	Washed	7/22/63	0.18
"	"	8/6/63	0.13
Lima bean	Shelled	9/3/63	<0.01
Celery	Unwashed	8/28/63	<0.01
"	Washed	8/28/63	<0.01

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CHEMICAL WEED CONTROL IN SWEETPOTATOES

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Sweetpotatoes are second only to Irish potatoes among important vegetable crops in Virginia. The state acreage over the past 45 years has ranged from 15,000 to 45,000, with the average in recent years of more than 20,000 acres, and showing a slight increase. Virginia produces 10 to 15% of the U. S. total crop, exceeded only by Louisiana and North Carolina. The annual cash return from sweetpotatoes to Virginia growers has ranged from 4 to over 7 million dollars during the past 20 years. A gradual decrease in sweetpotato acreage around Norfolk and other areas has been more than offset by an increase on the Eastern Shore of Virginia. As a result, almost 90% of the crop is now grown on the Eastern Shore.

There has been, in the past, considerable reluctance on the part of growers to use herbicides for the control of weeds in some vegetable crops, especially in the case of relatively high cash crops such as sweetpotatoes. Grower skepticism of herbicides on sweetpotatoes has been to a large extent justified and due to inconsistent weed control, possibility of crop injury, and additional cost from their use, as well as the fact that most growers have usually been able to handle the weed problems by cultivation and cultural methods.

However, as agricultural labor continues to decrease in availability and increase in cost, and as cultural practices, sweetpotato varieties, and weed problems change, the interest in and need for herbicides to assist growers in controlling weeds in this crop are increasing. It appears certain that the development of safe and effective chemicals will keep pace with this need.

Herbicides which have been used successfully on sweetpotatoes in some areas during past years include Alanap (NPA), Randox (CDA), and Chloro IPC (CIPC). While NPA and CIPC have been used with moderate success in the light soils of eastern Virginia, all of these materials are subject to erratic results during the summer months when sweetpotatoes are grown. Their period of effective weed control is seldom prolonged for more than a few weeks and under conditions of high rainfall or high temperatures, they may fail completely. Furthermore, both NPA and CIPC should be used on sweetpotatoes only in the granular form to prevent possible crop injury. This has also discouraged their use since application equipment has been limited.

There are three periods in the production of sweetpotatoes in eastern Virginia when herbicides could be logically and economically used; i.e. pre-transplant incorporation, at-transplanting, and at lay-by. Which application period or periods to be used in any situation would depend on herbicide safety and effectiveness, residual activity, effect of cultivation, rainfall and climatic conditions, cost and availability of labor, cultural practices, and personal opinions of growers. To provide maximum flexibility and effectiveness under all conditions, therefore, it is important to investigate all three methods of herbicide applications.

Pre-transplant Incorporation Experiment

Previous work has demonstrated that the sweetpotato is subject to injury

from some of the thiolcarbamates when applied and incorporated prior to transplanting. In an effort to evaluate the effect of this injury on yield and the possibility of delayed transplanting to prevent injury, a split plot trial was conducted with the following treatments:

Main plots:	Eptam	3 lbs/A
	Eptam	6 lbs/A
	R1607	3 lbs/A
	R1607	6 lbs/A
	Tillam	3 lbs/A
	Tillam	6 lbs/A
Sub plots:	Transplanted 0 weeks after application	
	Transplanted 1 week after application	
	Transplanted 2 weeks after application	
	Transplanted 4 weeks after application	

No untreated check was included. It was assumed, based on previous work, that Tillam caused no injury or growth suppression, especially at the low rate. Also, check plots were included in an adjacent experiment set out at the same time.

All treatments were applied as broadcast spray to a freshly worked, dry soil surface on June 19, 1963. Mechanical incorporation was done within minutes by double discing 3 to 4 inches deep. Chemical treatments were replicated three times and each plot was 12 ft. wide by 30 ft. long. One row of Nema-gold sweetpotatoes was set into each plot within a few hours of herbicide application. Additional rows were planted in each plot on June 26, July 3, and July 18.

No cultivation, weeding, or subsequent treatments were applied. The only weeds that occurred throughout the experiment were a few annual grasses (goosegrass and crabgrass) which appeared in plots treated with 3 lbs/A of Tillam. Even in this treatment, however, weed control was rated as very good at harvest time.

All plots were harvested at the same time on October 7. The average yield from each treatment is given in Table 1.

Table 1
Sweetpotato Yield in cwt/A from Preplant Incorporation of Thiolcarbamates,
Eastern Shore, 1963

Herbicide Treatment	June 19 (0 weeks)	Transplanting Date		
		June 26 (1 week)	July 3 (2 weeks)	July 18 (4 weeks)
Eptam 3 lbs/A	89	116	80	30
Eptam 6 lbs/A	66	67	60	15
R1607 3 lbs/A	74	106	99	30
R1607 6 lbs/A	75	45	65	19
Tillam 3 lbs/A	100	137	102	24
Tillam 6 lbs/A	108	143	120	33

There were highly significant differences in sweetpotato yield due to herbicide treatments and transplanting intervals. Tillam gave higher yields than Eptam or R1607 at all transplanting intervals except the final date. There was no significant difference between Eptam and R1607 at any interval. Differences in yield also occurred between rates, particularly at the second and third transplanting interval, in the case of Eptam and R1607. The 6 lbs/A rate of both herbicides reduced yields compared to the 3 lbs/A rate. The high rate of Tillam did not show lower yields at any interval compared to the 3 lbs/A rate. The sweetpotatoes transplanted one week after herbicide incorporation gave higher yields than when transplanted at any other time. There was no difference in yield between transplanting at time of application and two weeks later, but there was a sharp reduction when transplanting was delayed for four weeks.

Why sweetpotato yields were greater when transplanted on June 26 compared to the June 19 date is not clear. At least two explanations are possible. Even Tillam, which shows no injury or effect on sweetpotato foliage, may, even at the low rate, sufficiently inhibit early growth and development of the roots to result in a decreased yield. Other factors such as soil and climatic conditions may have been more favorable at or following the second transplanting interval than with the first. The fact that the mean yield for the unweeded and cultivated check plots from the experiment immediately adjacent, which was also transplanted on June 19, was 120 and 128 cwt./A, respectively, indicate that at least the first possibility, and perhaps a combination of the two, were contributing factors. Certainly weed competition did not play a part in this experiment.

If sweetpotato yield was reduced when transplanted immediately following incorporation of Tillam, it was no more serious at 6 lbs/A than at 3 lbs/A, and the injurious effect was apparently dissipated one week later. Eptam and R1607 treatments, on the other hand, tend to show yield reductions even from delayed transplanting, particularly at the 6 lbs/A rate.

Since the sweetpotatoes were all harvested at the same time, the delayed transplantings had a shorter growing season. Comparisons within herbicide treatments but between transplanting intervals, therefore, are not strictly valid, with the possible exception of between the first two intervals, when results show the reverse from the expected based on growing period alone.

At-transplanting Experiment

Nemagold sweetpotatoes were transplanted on June 19, 1963 in a Sassafras sandy loam soil on the Eastern Shore of Virginia. The soil had been freshly worked, soil moisture was good, but the surface was dry and loose. All herbicides were applied on June 19 soon after transplanting as broadcast preemergence treatments, except for treatments 1, 2, 6, 7, 11, 12, 16 and 17 (thiol-carbamates) which were incorporated immediately by cultivation.

All plots were 6 ft. (2 rows) wide by 30 ft. long. Treatments were arranged in a randomized block design with three replications. Table 2 presents the treatments and data summary, including the early crop injury rating (on July 2), the treatment yield means, and the grass control ratings

Table 2. Sweetpotato Injury, Yield (cwt/A), and Grass Control from At-transplanting Treatments, Eastern Shore, 1963

Herbicide Treatment			Crop Injury	Yield (cwt/A)	Grass Control	Sign. Diff. in Grass Con- trol (%)	
			July 2	Oct. 8	Oct. 7		
1	Eptam, Inc.	e.c. 3	10	150	8.00	b c d e f	
2	Eptam, Inc.	e.c. 6	8	155	8.00	b c d e f	
3	Eptam,	e.c. 3	10	166	6.67	f g h i j	
4	Eptam,	e.c. 6	9	123	6.67	f g h i j	
5	Eptam,	G	3	140	5.67	h i j k	
6	R1607, Inc.	e.c. 3	10	113	7.67	c d e f g	
7	R1607, Inc.	e.c. 6	9	119	8.00	b c d e f	
8	R1607	e.c. 3	10	151	6.33	f g h i j k	
9	R1607	e.c. 6	10	152	7.33	d e f g h	
10	R1607	G	3	134	5.67	h i j k	
11	Tillam, Inc.	e.c. 3	10	141	8.00	b c d e f	
12	Tillam, Inc.	e.c. 6	10	138	7.00	e f g h i	
13	Tillam	e.c. 3	10	114	6.67	f g h i j	
14	Tillam	e.c. 6	10	140	6.00	g h i j k	
15	Tillam	G	3	151	5.00	j k l	
16	R4572, Inc.	e.c. 4	10	150	7.00	e f g h i	
17	R4572, Inc.	e.c. 8	10	136	7.33	d e f g h	
18	R4572	e.c. 4	10	130	7.00	e f g h i	
19	R4572	e.c. 8	10	138	8.00	b c d e f	
20	R4572	G	4	153	7.67	c d e f g	
21	Amiben	e.c. 4	10	157	9.67	a b	
22	Amiben	e.c. 8	9	131	10.00	a	
23	Amiben	e.c. 16	8	120	10.00	a	
24	Amiben	G	4	148	8.00	b c d e f	
25	Casoron	WP	4	7	132	5.67	h i j k
26	Casoron	WP	6	5	109	6.00	g h i j k
27	Casoron	G	4	6	122	6.33	f g h i j k
28	Dacthal	WP	4	10	142	6.67	f g h i j
29	Dacthal	WP	8	10	128	8.00	b c d e f
30	Diphen.	WP	2	10	138	9.67	a b
31	Diphen.	WP	4	10	126	9.67	a b
32	Diphen.	WP	8	10	131	10.00	a
33	Herban	WP	2	10	136	8.67	a b c d e
34	Herban	WP	4	10	116	9.33	a b c
35	Linuron	WP	1	9	122	6.67	f g h i j
36	Linuron	WP	2	8	118	9.00	a b c d
37	Swep	e.c. 6	6	100	6.67	f g h i j	
38	Swep	e.c. 8	4	89	8.00	b c d e f	
39	Swep	G	6	10	136	4.67	k l
40	Trifl.	e.c. 2	10	145	10.00	a	
41	Trifl.	G	2	10	134	7.33	d e f g h
42	Trifl.	G	4	10	152	9.00	a b c d
43	Prom.	WP	2	6	114	6.67	f g h i j
44	Prom.	G	2	9	119	3.67	l m
45	Prom.	G	4	8	118	6.33	f g h i j k
46	CIPC	G	4	10	136	6.33	f g h i j k
47	NPA	G	4	10	151	6.67	f g h i j
48	CDA	G	4	10	128	5.33	i j k

at harvest, with their statistical differences. Crop injury and grass control ratings are based on a scale in which 0 = complete kill and no grass control, and 10 = no effect and complete grass control.

While several treatments showed considerable early burning or injury, by harvest there were no apparent treatment effects on sweetpotato foliage and no significant difference in yield was obtained, with the exception of Amiben which still showed considerable leaf curl and growth modification, especially at the high rate. None was apparent at the low commercially practical rate.

In spite of the lack of significance in the yield data, on the basis of early crop injury, which often was accompanied by a non-significant yield reduction, and the lack of good seasonal grass control, it is probably justified to discontinue any further extensive investigations on several of these herbicides for this purpose. Those included in this test which are considered not to be worthy of further work on control of weeds in sweetpotatoes at transplanting in eastern Virginia include Casoron, Linuron, Swep, Prometryne, CIPC, NPA, and CDAA.

The most promising materials from the standpoint of consistent weed control and crop safety include Amiben, Diphenamid, Dacthal, Herban, and Trifluralin. All four thiolcarbamates included in this trial were fairly promising and about equal in grass control. Slight early injury or leaf darkening occurred when the high rate of Eptam or R1607 was incorporated by cultivation, but was only temporary and had no apparent effect on yield. Except for R4572, incorporation tended to improve weed control. It was somewhat surprising to note that grass control from the granular formulations of the thiolcarbamates was inferior to the sprays except in the case of R4572. Granular formulations of Amiben, Swep, Trifluralin, and Prometryne were generally significantly inferior in grass control to equal rates of spray applications. Casoron was equal or slightly superior in granular form.

While the Duncan multiple range test is given for grass control ratings in Table 2, a simple way of determining whether two numbers are significantly different is that any difference which exceeds 1.67 is significant at the 5% level.

Lay-by Experiment

Nemagold sweetpotatoes were transplanted on May 29, 1963 immediately adjacent to the at-transplanting experiment. The plots were 6 ft. by 30 ft. and arranged in a randomized block with three replications. The entire field was cultivated periodically until normal lay-by, July 23, when all herbicides in Table 3 were applied soon after the final cultivation. Treatments 3 and 13 were incorporated within minutes by an additional cultivation.

Because of the fairly dry season following application and the shading from sweetpotato vines which grew over the alleys, very few weeds or grasses came in, so no data were obtained on weed control. The yield data taken at harvest on September 27 showed no significant differences between any treatments. The only treatments which suggest a fairly sharp and consistent decrease in yield are treatments 23 and 24 (Linuron at 1 and 2 lbs/A, respectively). Other than this observation, the only conclusion to be drawn from this experiment is that all other treatments used appear to be safe on sweet-

Table 3 Sweetpotato Yield in cwt/A from Lay-by Treatments,
Eastern Shore, 1963

Number	Herbicide Treatment		Yield (cwt/A)	
1	Eptam	e.c.	3	135
2	Eptam	G	3	132
3	Eptam, Inc.	e.c.	3	149
4	Tillam	e.c.	3	149
5	Tillam	G	3	185
6	R1607	e.c.	3	130
7	R1607	G	3	141
8	R4572	e.c.	3	151
9	R4572	G	3	160
10	Trifluralin	e.c.	1	180
11	Trifluralin	e.c.	2	180
12	Trifluralin	G	1	170
13	Trifluralin, Inc.	e.c.	1	151
14	Diphenamid	WP	2	188
15	Diphenamid	WP	4	159
16	Diphenamid	G	2	176
17	Dacthal	WP	4	186
18	Dacthal	WP	8	130
19	Amiben	e.c.	4	145
20	Amiben	G	4	194
21	Casoron	WP	4	161
22	Casoron	G	4	146
23	Linuron	WP	1	118
24	Linuron	WP	2	112
25	Swep	G	6	149
26	Prometryne	G	2	152
27	Herban	WP	2	135
28	Herban	WP	4	143
29	NFA	G	6	153
30	Check			179

Summary and Conclusions

1. While additional work is justified, these preliminary results indicate that yields may be decreased if transplanting of sweetpotatoes follows immediately or is delayed for two weeks after soil incorporation of thiolcarbamates. This is particularly true from an application of 6 lbs/A of Eptam and R1607.
2. Foliage response is apparently not a reliable criterion by which to evaluate sweetpotato injury from thiolcarbamates.
3. Tillam, while being somewhat less effective in control of some weeds than Eptam or R1607, has considerably more selectivity on sweetpotatoes.
4. Any effect which Tillam may have had on sweetpotato yields when transplanted immediately, was not evident when transplanting was one week later.

5. Several herbicides may be safely and effectively used at transplanting time to eliminate or reduce hand weeding and cultivation of sweetpotatoes.
6. The most promising materials in the at-transplanting experiment were Diphenamid, Amiben, Trifluralin, Herban, Dacthal, and the incorporated thiolcarbamates.
7. All of the other herbicides tested gave early crop injury or poor weed control.
8. Dry weather, resulting in poor weed development, prevented any observations on weed control effectiveness from the lay-by treatments.
9. Sweetpotatoes appeared to be tolerant of all treatments applied at lay-by, with the possible exception of Linuron.

COMBINATIONS OF DCPA AND 2,4-D FOR WEED CONTROL
IN FIELD AND SWEET CORN

R. D. Ilnicki, J. F. Ellis and B. Metzger¹

There is a growing list of herbicides, experimental and label approved, being made available for pre-emergence weed control in corn. Some of these effect only short season control and additional mechanical control is required; others are capable of producing full season control with little or no cultivation necessary. With the latter, the problem of residual amounts of herbicide remaining in the soil has concerned research workers especially if sensitive crops are to follow the crop where the herbicide was used.

For almost two decades 2,4-dichlorophenoxyacetic acid (2,4-D) has been used successfully for weed control in corn. Some of its limitations are failure to adequately control grassy weeds and the potential danger of effecting corn injury when excessive rains follow pre-emergence applications.

Recently, dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) has proved to be an effective and versatile herbicide in many weed-crop situations. One serious limitation is that common ragweed and smartweed are not adequately controlled.

It was reasoned from these observations that combinations of these two herbicides may prove effective for weed control in corn. It was also reasoned that rates of each herbicide could be reduced when applied in combination.

Materials and Methods

Experiments have been underway at the New Jersey Agricultural Experiment Station for the last three years in which combinations of DCPA and 2,4-D were applied pre-emergence to corn.

In one experiment initiated in 1961, DCPA was applied at 4 and 8 pounds and 2,4-D at 1-1/2 pounds, each alone, and in combination. These treatments, part of a general pre-emergence evaluation test, were made two days after planting.

In 1962, DCPA was applied at rates of 4, 6, 8, 9, and 12 pounds and 2,4-D at 1/2, 1, and 1-1/2 pounds. In addition, applications of DCPA at the three lowest rates and 2,4-D at all rates were made in all possible combinations. These were applied immediately after planting.

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An experiment similar to the one in 1962 was conducted in 1963 on sweet corn. One exception, however, was the elimination of the 9-pound rate of DCPA applied alone.

The design of all experiments was a randomized block with three or four replications. DCPA was applied as the 75% wettable powder and 2,4-D was the 2-ethyl hexyl ester. Applications of all treatments are expressed in pounds per acre of active ingredient or acid equivalent and were made in 40 gpa. Combination treatments were applied separately.

Weed control and crop injury ratings were made periodically using the scale 0 to 10, where 0 = no effect, 10 = stand/vigor reduced 100% or complete kill.

Field corn was harvested from the two center rows of the four-row plots which were 20 feet in length. Yields were determined by obtaining ten butt samples and drying these to constant weight, then converting field weights to bushels per acre at 15-1/2% moisture.

Sweet corn plots were three rows wide and 15 feet in length. Yields were determined by harvesting only marketable ears from all rows of the plot and recorded weights converted to hundred-weights (cwt) per acre.

For the sake of brevity, details concerning planting, application, observation, and harvest dates, soil type and location of experiments have been omitted here. These may be found in the summary tables.

Results and Discussion

Summaries of weed control and crop response are presented in Tables I, II, and III for 1961, 1962, and 1963, respectively. For ease, results of each year will be discussed separately.

1961

From Table I it is evident that additions of 2,4-D to DCPA increased herbicidal effectiveness above that obtained from either herbicide applied alone. This was primarily due to the control of a broader spectrum of weeds.

At the time ratings were made, reductions in crop injury were greater from the combinations but these reductions were not manifested in yield reductions.

Table I. Weed Control in Field Corn - 1961.

Variety - N.J. No. 8
 Planted - May 23
 Treated - May 25
 Rated - July 11*

Harvested - October 10-12
 Location - Jamesburg
 Soil Type - Sassafras Sandy Loam

Treatment	Rate, lb/A	Weed Control ¹		Crop Response		Yield, Bu/A
		Broad- leaves	Grasses	Stand ²	Vigor ³	
1. DCPA	4	8.0	5.8	0.0	0.8	69.6
2.	8	9.0	6.3	0.3	0.5	75.3
3. 2,4-D	1-1/2	8.8	5.0	0.8	1.2	77.8
4. DCPA + 2,4-D	4 + 1-1/2	9.1	6.4	0.3	1.8	64.0
	8 + 1-1/2	9.5	7.8	0.3	2.8	75.1
5. Check - Cultivated		9.5	6.2	0.3	1.8	72.0

* All data are the average of four replications.

¹ Based on scale 0 to 10; 0 = no effect, 10 = stand/vigor reduced 100%.

² Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%.

³ Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

Weed spectrum - lambsquarters, pigweed, barnyardgrass, crabgrass, and some carpetweed.

Table II. Weed Control in Field Corn - 1962.

Variety - N.J. No. 9
 Planted - May 23
 Treated - May 23
 Rated - June 26*

Harvested - October 29-30
 Location - Adelphia
 Soil Type - Freehold Loam

Treatment	Rate, lb/A	Weed Control				Crop Response		Yield, Bu/A
		Broadleaves		Grasses		Stand ¹	Vigor ²	
		Stand ¹	Vigor ²	Stand ¹	Vigor ²			
1. DCPA	4	5.7	2.3	6.5	1.8	0.4	0.3	95.1
2.	6	7.0	3.7	5.9	2.3	1.1	0.4	80.2
3.	8	7.2	3.7	5.9	1.7	1.0	0.3	80.1
4.	9	7.8	4.2	8.1	2.1	1.0	0.3	93.5
5.	12	8.1	4.7	9.0	2.8	1.0	0.3	93.9
6. 2,4-D	1/2	6.4	3.7	8.6	2.3	0.4	0.1	59.4
7.	1	7.9	4.0	7.8	2.4	1.3	0.2	95.8
8.	1-1/2	8.0	5.3	8.6	3.8	0.9	0.0	115.5
9. DCPA + 2,4-D	4 + 1/2	7.4	3.8	8.8	3.4	1.0	0.1	86.6
10.	4 + 1	8.0	5.9	8.8	2.6	0.2	0.0	120.5
11.	4 + 1-1/2	9.2	6.4	9.2	4.1	0.6	0.0	113.1
12.	6 + 1/2	9.0	5.7	9.2	3.5	0.2	0.2	106.3
13.	6 + 1	8.8	5.7	8.4	4.0	0.2	0.1	106.2
14.	6 + 1-1/2	9.6	7.3	9.7	3.8	0.7	0.1	116.3
15.	8 + 1/2	8.4	5.1	8.9	2.4	0.7	0.0	100.9
16.	8 + 1	8.3	5.7	9.3	3.4	1.2	0.1	96.0
17.	8 + 1-1/2	9.3	6.1	9.1	3.1	0.7	0.0	115.9
18. Check - cultivated								107.5
LSD	0.05							25.1
	0.01							33.5

* Average of three ratings of each of three replications.

¹ Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%.

² Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

Weed spectrum--predominantly pigweed; some lambsquarters; little barnyardgrass & crabgrass.

Table III. Weed Control in Sweet Corn - 1963.

Variety - Iochief

Planted - May 6

Treated - May 6

Rated - June 18*

Harvested - August 7

Location - Adelphia

Soil Type - Freehold Loam

Treatment	Rate, lb/A	Weed Control				Crop Response		Yield, CWT/A
		Broadleaves		Grasses		Stand ¹	Vigor ²	
		Stand ¹	Vigor ²	Stand ¹	Vigor ²			
1. DCPA	4	7.0	7.0	8.7	6.5	0.3	1.3	48.1
2.	6	7.8	7.1	9.1	6.8	0.8	3.3	73.8
3.	8	8.4	7.4	9.8	7.8	1.3	3.5	63.8
4.	12	9.3	9.1	9.8	9.5	1.3	3.3	82.3
5. 2,4-D	1/2	7.9	5.0	5.1	4.3	0.8	3.3	72.6
6.	1	8.4	6.0	8.5	6.5	0.3	3.5	66.2
7.	1-1/2	8.9	7.9	8.9	7.3	1.8	4.8	54.3
8. DCPA + 2,4-D	4 + 1/2	9.0	8.1	9.5	7.8	1.0	3.5	50.6
9.	4 + 1	9.7	8.7	9.8	8.8	1.3	4.0	79.4
10.	4 + 1-1/2	9.9	9.1	9.8	8.3	1.0	4.3	78.8
11.	6 + 1/2	9.5	8.6	9.3	8.0	0.5	3.8	82.7
12.	6 + 1	9.8	8.5	9.6	8.0	0.8	4.0	62.5
13.	6 + 1-1/2	9.9	8.8	9.9	8.5	0.8	4.3	87.8
14.	8 + 1/2	9.5	9.1	9.5	8.8	0.3	4.5	80.2
15.	8 + 1	9.9	9.5	9.6	8.3	1.5	4.8	72.0
16.	8 + 1-1/2	9.9	9.5	9.8	8.5	0.8	4.3	65.2
17. Check - cultivated		0.0	0.0	0.0	0.0	0.5	1.8	27.6
LSD 0.05								30.8
0.01								40.4

* Average of four replications and one rating per replication.

1 Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%.

2 Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

Weed Spectrum--barnyardgrass and pigweed with some lambsquarters.

1962

Details of the work conducted this year are presented in Table II. From these data it can be seen that weed control with the combinations of DCPA and 2,4-D was greater than that produced by either herbicide applied alone. Furthermore, the degree of control obtained with each combination tested was greater than that obtained by either component when used alone.

Because of an unusually dry spring the increases in weed control were not reflected in yield. The trends, however, are worthy of note.

1963

Since sweet corn is more sensitive to 2,4-D than field corn and since the herbicides commonly used in field corn would potentially present a residual problem to subsequent sensitive crops, it was felt that combinations of DCPA and 2,4-D would be desirable in its culture.

Combinations of DCPA and 2,4-D proved effective for weed control in sweet corn (Table III). There was some initial decrease in vigor of plants from the combinations, but from the data it is obvious that 2,4-D contributed more to this decrease than DCPA. This initial stunting was short-lived and was later outgrown. It did not reflect in yield reduction.

There were significant increases in yield as a result of increases in weed control.

General Discussion

From the various experiments it was determined that increases in weed control could be obtained from combinations of DCPA and 2,4-D. These increases may not appear to be great; however, although not apparent in the data presented here, there was an increase in the duration of weed control. This duration in control was greater than that obtained from either herbicide used alone. Furthermore, there is no potential residue problem to beans and cole crops, which sometime follow a crop like sweet corn, or to small grains which follow field corn.

A fact also worthy of comment is that both field and sweet corn tolerate rates of DCPA in excess of 9 pounds per acre.

Summary and Conclusions

Experiments were conducted for three years in which various combinations of DCPA and 2,4-D were evaluated for weed control and crop safety in field and sweet corn. From these experiments it was observed that the following combinations proved to be effective

PREEMERGENCE WEED CONTROL OF ANNUAL WEEDS IN SWEET CORN

M.F. Trevett and William Gardner^{1/}

INTRODUCTION

This paper is a report of a test designed to compare annual weed control obtained with a standard two pound per acre rate of Atrazine with control from lower rates of Atrazine in combination with other herbicides, or with combinations of other herbicides. The herbicides used are listed in Table 1.

PROCEDURE

Sweet corn was planted 17 June, 1963 in a loam soil. Treatments were replicated eight times. Rainfall is given in Table 2.

Herbicides were applied with one pass of a small plot sprayer at 40 pounds pressure and fifty gallons per acre volume. Planting (PL) applications were made 20 June 1963, preemergence applications (Pre) were made 24 June 1963.

The principal weeds were: Lambsquarters pigweed (Chenopodium album L.), Redroot pigweed (Amaranthus retroflexus L.), Wild Rutabaga (Brassica rapa L.), and Barnyard grass (Echinochloa crusgalli (L.) Beauv.).

Counts of annual grass were made the week of 5 August 1963. Percent broadleaf weed control was estimated 30 July 1963.

RESULTS

In this test stand of corn was not affected by treatment, hence stand data are not given.

Broadleaf weed control

All treatments except planting applications of one and two pounds of Amiben, and 0.4 pounds Diuron plus 1 percent WK gave excellent broadleaf weed control, Table 3.

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Treatments giving satisfactory annual broadleaf weed control included:

6# Swep EC plus 1# Amiben	2# Atrazine
6# Swep EC plus 2# Amiben	1# Atrazine
6# Swep EC	1# Atrazine plus 1# Amiben
1# Atrazine plus 2# Amiben	1# Atrazine plus 1% WK
4# 2,4-DEP plus 3# DNBP	1# Linuron plus 1% WK
0.5# Paraquat plus 1# Atrazine	4.5# DNBP
	3# DNBP

Combinations of herbicides did not significantly increase broadleaf weed control over that obtained by the most effective partner in the combination, since the most effective partner alone gave over 90 percent control, Table 3. This left small chance for improvement. For the same reason a surfactant added to a pre-emergence application of 1 pound of Atrazine did not significantly increase broadleaf weed control over Atrazine alone.

Amiben gave poor control of Wild rutabaga.

Annual grass control

Six pounds of Swep EC plus 2 pounds of Amiben applied at planting gave significantly better Barnyard grass control than all other treatments (Table 4) except:

- 6# Swep EC plus 1# Amiben at planting
- 1# Linuron plus 1% WK, preemergence
- 2# Atrazine at planting
- 6# Swep EC at planting

Treatments that did not differ significantly in annual grass control included:

- 6# Swep EC plus 1# Amiben, planting
- 1# Linuron plus 1% WK, preemergence
- 2# Atrazine, planting
- 6# Swep EC, planting
- 1# Atrazine plus 2# Amiben, planting
- 1# Atrazine plus 1# Amiben, planting
- 4# 2,4-DEP plus 3# DNBP, preemergence
- 4.5# DNBP, preemergence

The addition of surfactant WK to one pound of Atrazine applied preemergence did not significantly increase annual grass control over that obtained with one pound of Atrazine without surfactant applied at planting.

One or two pounds of Amiben plus one pound of Atrazine applied at planting significantly increased annual grass control over that obtained with one pound of Atrazine alone, Table 4.

It appears that a higher rate of Amiben (three or four pounds) will be needed in this combination to obtain a more satisfactory level of control. Neither one or two pounds of Amiben applied in addition to six pounds Swep EC increased annual grass control over Swep alone. A more critical test might prove the Amiben-Swep combination better than Swep alone.

Four pounds of 2,4-DEP plus 3 pounds DNBP did not significantly increase annual grass control over that obtained with 4.5 pounds DNBP applied alone, preemergence, Table 4.

Yields

Six pounds Swep EC applied at planting, 4.5 pounds DNBP applied preemergence, and 1 pound Linuron plus 1 percent WK applied preemergence gave significantly higher yields than planting application of one or two pounds of Amiben, and preemergence application of 0.5 pounds Paraquat plus 1 pound Atrazine, and 0.4 pounds Diuron plus 1 percent WK, Table 5.

Six pounds of Swep EC applied at planting, 4.5 pounds DNBP applied preemergence, and 1 pound Linuron plus 1 percent WK applied preemergence, did not differ significantly from the remaining treatments in effect on yield.

Five percent of the plants in the 2,4-DEP plus DNBP treatment were rattailed, but not seriously enough to significantly reduce yields.

CONCLUSIONS

The excellence of Atrazine as a corn herbicide is undisputed. However, in rotations in which snap beans immediately follow corn, growers and Extension personnel occasionally report slight to moderate Atrazine injury to the beans. The reported injury has usually been found in fields in which corn has received two or more pounds of Atrazine per acre.

Annual weed control equivalent to that obtained with two pounds per acre of Atrazine was obtained in 1963 tests with either one pound per acre rate of Atrazine plus one or two pounds of Amiben, six pounds of Swep EC with or without one or two pounds of Amiben, one pound of Linuron plus 1 percent surfactant WK (Linuron without WK was not included in the test), 4.5 pounds DNBP, or 3 pounds DNBP plus 4.0 pounds 2,4-DEP.

Table 1. Materials Used in Sweet Corn.

AMIBEN	3-amino-2,5-dichlorobenzoic acid
ATRAZINE	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
DIURON	3-(3,4-dichlorophenyl)-1,1-dimethylurea
DNBP	4,6-dinitro-o-secondary butylphenol
LINURON	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
PARAQUAT	1,1'-dimethyl-4,4'-dipyridylium cation
SWEP EC	Emulsifiable concentrate of methyl 3,4-dichlorocarbanilate
2,4-DEP	Tris(2,4-dichlorophenoxyethyl) phosphite
WK	DuPont Surfactant WK

Table 2. Rainfall: May, June, July, August, 1963,
Monmouth, Maine.

Date	Inches	Date	Inches
May 18	.82	July 21	.02
21	.44	29	.06
22	.03	30	.04
23	.02	August 1	.19
29	.17	3	.33
31	.02	4	.50
June 6	.28	5	.35
8	.04	7	.32
12	.08	9	.04
18	.22	11	.03
20	.34	13	1.01
21	.10	14	.85
27	.05	15	.04
July 1	.47	17	.28
7	.48	19	.11
8	.40	20	.24
14	.05	22	.18
15	.01	23	.03
18	.16	24	.02
20	.03	29	.02

Table 3. Percent Control of Annual Broadleaf Weeds in Sweet Corn.

Acre rate of active ingredient: lbs.		Means converted to angles	Means: %
6# Swep EC + 1# Amiben,	PL ^{1/}	79.68	96.8
6# Swep EC + 2# Amiben,	PL	79.46	96.6
6# Swep EC,	PL	79.09	96.4
1# Atrazine + 2# Amiben,	PL	78.76	96.2
4# 2,4-DEP + 3# DNBP,	Pre	78.16	95.8
0.5# Paraquat + 1# Atrazine,	Pre	78.07	95.7
2# Atrazine,	PL	77.89	95.6
1# Atrazine,	PL	77.89	95.6
1# Atrazine + 1# Amiben,	PL	77.23	95.1
1# Atrazine + 1% WK,	Pre	76.27	94.3
Hand hoed		74.69	93.0
1# Linuron + 1% WK,	Pre	71.23	89.6
4.5# DNBP,	Pre	71.22	89.6
3# DNBP,	Pre	70.42	88.7
2# Amiben,	PL	30.68	26.0
1# Amiben,	PL	24.88	17.7
0.4# Diuron + 1% WK	PL	19.49	11.1
L.S.D. 5%		8.48	Not computed

^{1/} See Table 5 for details.

^{2/} Duncan's Multiple Range Test. Counts made: 30 July '63. 22.7 broadleaf weeds per square foot.

Table 4. Percent Control of Annual Grass in Sweet Corn.

Rate of active ingredient per acre: lbs.		Means converted to angles	Means: %
6# Swep EC + 2# Amiben, Hand hoed	PL ^{1/}	82.53 ^{2/}	98.3 ^{2/}
6# Swep EC + 1# Amiben,	PL	72.65	91.1
1# Linuron + 1% WK,	Pre	68.60	86.6
2# Atrazine,	PL	66.55	84.1
6# Swep EC,	PL	64.52	81.5
1# Atrazine + 2# Amiben,	PL	59.83	74.7
1# Atrazine + 1# Amiben,	PL	56.58	69.6
4# 2,4-DEP + 3# DNBP,	Pre	52.86	63.5
4.5# DNBP,	Pre	52.21	62.4
3.0# DNBP,	Pre	52.03	62.1
0.5# Paraquat + 1# Atrazine,	Pre	38.16	38.2
1# Amiben,	PL	36.71	35.7
1# Atrazine + 1% WK,	Pre	35.92	34.4
1# Atrazine,	PL	33.80	30.9
2# Amiben,	PL	26.63	20.1
0.4# Diuron + 1% WK,	Pre	23.47	15.8
		21.47	13.4
L.S.D. 5%		19.90	Not computed

^{1/} See Table 5.

^{2/} Duncan's Multiple Range Test. 9.6 annual grass plants per square foot; counts made week of 5 August '63.

Table 5. Yield of Sweet Corn Per 25 Feet of Row.

Acre rate of active ingredient: lbs./ $\frac{1}{2}$		Yield lbs. snapped ears per 25' of row	Rank	
			Annual grass control	Annual broad-leaf control
6# Swep EC,	PL	30.2	6	3
4.5# DNBP,	Pre	29.9	10	13
1# Linuron + 1% WK,	Pre	29.4	4	14
2# Atrazine,	PL	29.0	5	7
4# 2,4-DEP + 3# DNBP,	Pre	28.7	9	5
6# Swep EC + 1# Amiben,	PL	28.6	3	1
1# Atrazine + 1% WK,	Pre	27.1	14	10
1# Atrazine,	PL	26.9	15	8
3# DNBP,	PL	26.7	11	14
1# Atrazine + 1# Amiben,	PL	26.5	8	9
1# Atrazine + 2# Amiben,	PL	26.3	7	4
6# Swep + 2# Amiben,	PL	25.4	1	2
Hand hoed		24.2	2	11
2# Amiben,	PL	22.8	16	15
0.5# Paraquat + 1# Atrazine,	Pre	22.7	12	6
0.4# Diuron + 1% WK,	Pre	20.0	17	17
1# Amiben,	PL	19.3	13	16
L.S.D. 5%		5.1		

1/ Planted: 17 June '63. Pre = applied preemergence 24 June, weeds in cotyledonary stage. PL = applied 20 June, weeds not emerged. Variety: Carmel Cross.

2/ Duncan's Multiple Range Test: Means within same brackets do not differ significantly at the 5% level.

EFFECT OF SEVERAL HERBICIDE TREATMENTS ON WEED CONTROL AND THE PRODUCTION
AND ROOTING OF TENNESSEE BEAUTY STRAWBERRY RUNNERS

Oscar E. Schubert¹

The primary purpose of this experiment was to determine which herbicide treatments would give the best weed control with the least injury to the strawberry plants and their runners.

METHODS AND MATERIALS

Tennessee Beauty strawberry plants were set April 24-5, 1963 on a heavy clay loam soil at the West Virginia Horticulture Farm, Morgantown, West Virginia. The soil was disked the day before setting. The field was divided into four blocks or replications. Each replication was divided into plots 7 feet wide and 30 feet long. Thirteen strawberry plants were set in a single row down the middle of each 7 x 30-foot plot. The plants were spaced 24" apart in the row starting 3 feet inside the plot for the first plant set. This provided a buffer space 3 feet in width at the beginning and end of each plot.

The plots were weeded with a power cultivator and a hoe on May 6, 1963. The herbicide treatments (Table 1) were applied at random within each replication. The granular herbicides were applied with a herbicide distributor designed for small experimental plots. Herbicides formulated as wettable powders and emulsifiable concentrates were applied with a boom attached to a power sprayer.

During the first two weeks of October, 1963, the strawberry mother plants were pulled and weighed after removing all loose soil. The runner plants were also pulled, weighed, and counted. The runner plants which were rooted or starting to root were counted separately from those without roots.

After the strawberry plants were taken out, the grassy and broadleaf weeds were pulled, counted, and weighed in two randomized rectangular subplots 3 x 4 feet each.

All data reported was analyzed by an analysis of variance and the treatment means were compared at the 5% level of significance using Tukey's test of "All Comparisons Among Means" as described by Snedecor.

RESULTS AND DISCUSSION

Total Number of Strawberry Runner Plants (Table 2)

Strawberry plants of treatment 6 (diphenamid 6 lb/A applied 5 weeks after setting) produced a significantly higher number of runner plants than treatments:

- 20 - solan + solan
- 16 - dinoben, ec
- 19 - swep + swep
- 3 - 2,4-DEP + diphenamid
- 17 - dinoben, G
- 18 - dinoben, ec + diphenamid
- 12 - diphenamid + diphenamid--two 3 lb. applications
2 and 5 weeks after setting
- 14 - diphenamid + simazine

Table 1. Herbicide treatments, rates and application dates for Tennessee Beauty strawberry plants set April 24-5, 1963.

Treatment No.	Herbicide	Rate ai lb/A	Application dates	Application procedure
1	Check	-----	-----	Hoe as needed for control.
2	DCPA 75 wp +	9 +	May 8	Mix and spray together.
	Diphenamid 80 wp	3	May 8	
3	2,4-DEP 2 ec +	4 +	May 8	" " " "
	Diphenamid 80 wp	3	May 8	
4	Tillam 10 G +	5 +	May 7	Soil incorporate within 15 min. Then spray diphenamid.
	Diphenamid 80 wp	3	May 8	" " " "
5	R-1607 10 G +	5 +	May 7	" " " "
	Diphenamid 80 wp	3	May 8	" " " "
6	Diphenamid 80 wp	6	May 31	Hoe. Then spray diphenamid.
7	Swep 5G +	6 +	May 7	Apply swep to soil surface but do not incorporate.
	Diphenamid 80 wp	3	May 8	Then spray diphenamid.
8	Tillam 10 G +	5 +	May 7	Soil incorp. within 15 min.
	Simazine 80 wp	1	May 31	Spray simazine later.
9	R-1607 10 G +	5 +	May 7	" " " "
	Simazine 80 wp	1	May 31	" " " "
11	DCPA 75 wp +	9 +	May 8	Mix and spray together.
	2,4-DEP 2 ec	4	May 8	
12	Diphenamid 80 wp +	3 +	May 8	Spray second 3-pound appl. 3-4 wks. later.
	Diphenamid 80 wp	3	May 31	
13	Diphenamid 80 wp	6	May 8	Spray after setting plants.
14	Diphenamid 80 wp +	6 +	May 8	Spray diphenamid after set.
	Simazine 80 wp	1	May 31	Spray simazine later.
15	Diphenamid 80 wp	12	May 8	Spray after setting.
16	Dinoben 2 ec	4	May 8	" " " "
17	Dinoben 10 G	4	May 7	Broadcast after setting.
18	Dinoben 2 ec +	4 +	May 8	Mix and spray together.
	Diphenamid 80 wp	3	May 8	
19	Swep 5G +	6 +	May 7	Broadcast. Apply 6 lbs. after setting. 2nd 6 lb. appl. after 1st weeds appear. No soil incorp. at either time.
	Swep 5G	6	July 1	
20	Solan 4 ec	4 +	May 31	Spray when grasses 1 in. tall. Repeat later as above.
	Solan 4 ec	4	July 2	
22	EPTC 5G +	5 +	May 31	Broadcast separately and soil incorp. within 15 min. with rake to 2-in. depth. Delay application until 4-5 weeks after setting.
	Simazine 4G	1	May 31	Incorp. EPTC within 15 min. Apply simazine as a spray. Delay appl. until 4-5 wks. after setting.
23	EPTC 5G +	5 +	May 31	
	Simazine 80 wp	1	May 31	
24	SD-7961 5G	2	May 31	Broadcast 4-5 wks. after set. Do not soil incorp.

Table 2. Effect of several herbicide treatments on Tennessee Beauty strawberry plants.

No.	Treatment Herbicides applied	Average weight of strawberry plants		Average number of runner plants ¹	
		Mother plants (grams)	Runner plants (grams)	Rooted	Total
1	Hoed Check	347 a	476 ab	86 ab	125 ab
2	DCPA + diphenamid	249 ad	260 ad	76 ab	103 ac
3	2,4-DEP + diphenamid	162 bd	91 cd	27 bc	32 cd
4	Tillam + diphenamid	192 bd	222 ad	60 ac	80 ad
5	R-1607 + diphenamid	151 bd	190 bd	48 ac	79 ad
6	Diphenamid, 5wks. post-setting	274 ac	502 a	122 a	163 a
7	Swep + diphenamid	178 bd	244 ad	72 ac	92 ad
8	Tillam + simazine	161 bd	191 bd	68 ac	84 ad
9	R-1607 + simazine	197 ad	245 ad	90 ab	111 ac
11	DCPA + 2,4-DEP	173 bd	156 cd	52 ac	66 ad
12	Diphenamid + Diphenamid	206 ad	207 ad	49 ac	57 bd
13	Diphenamid, 2 wks. post-setting	196 ad	228 ad	64 ac	87 ad
14	Diphenamid + simazine	180 bd	161 cd	45 ac	60 bd
15	Diphenamid, 12 lb/A post-set	170 bd	194 bd	44 ac	74 ad
16	Dinoben, ec	170 bd	60 d	26 bc	27 cd
17	Dinoben, G	219 ad	108 cd	35 bc	46 bd
18	Dinoben, ec + diphenamid	166 bd	122 cd	32 bc	48 bd
19	Swep + swep	168 bd	101 cd	25 bc	31 cd
20	Solan + solan	116 d	36 d	13 c	15 d
22	EPTC + simazine, G	235 ad	377 ac	98 ab	134 ab
23	EPTC + simazine, wp	285 ab	314 ad	62 ac	104 ac
24	SD-7961	132 cd	148 cd	44 ac	64 ad

D=153

D=300

Treatment averages followed by the same letter are not significantly different from each other using Tukey's test of "All Comparisons Among Means" as described by Snedecor.

¹Before statistical analyses, the number of runner plants were transformed by $x = \sqrt{y + 1}$ where y is the original number.

Total Number of Strawberry Runner Plants (Table 2) Continued

Two treatments: 22 (EPTC + simazine, G) and 1 (hoed check) had higher numbers of runner plants than treatments 20, 16, 19 and 3, listed previously.

Three treatments: 23 (EPTC + simazine, wp), 9 (R-1607 + simazine), and 2 (DCPA + diphenamid) had higher numbers of runner plants than treatment 20 (solan + solan).

Strawberry plants of only four treatments (3, 16, 19, 20) produced significantly less runner plants than the check indicating that 18 other herbicide treatments did not decrease runner plant formation more than hoeing.

Number of Rooted Strawberry Runners (Table 2)

Strawberry plants of treatment 6 (diphenamid 6 lb/A ai applied 5 weeks after setting) had a significantly higher number of rooted runners than treatments:

- 20 - solan + solan
- 19 - swep + swep
- 16 - dinoben, ec
- 3 - 2,4-DEP + diphenamid
- 18 - dinoben, ec + diphenamid
- 17 - dinoben, G

Four treatments: 22, 1, 9 and 2 (EPTC + simazine, G; hoed check; R-1607 + simazine; and DCPA + diphenamid, respectively) had higher numbers of rooted runner plants than treatment 20 (solan + solan).

Under the conditions of this experiment only one treatment significantly reduced the number of rooted runners. The treatment means in Table 2 indicate possible effects on runner rooting if a greater number of observations had been taken or the number of replications increased.

Weights of Strawberry Runner Plants (Table 2)

Weights of runner plants from treatment 6 (diphenamid 6 lb/A ai applied 5 weeks after setting) were significantly higher than twelve herbicide treatments (20, 16, 3, 19, 17, 18, 24, 11, 14, 5, 8 and 15, in order of increasing average weights).

Weights of runner plants from treatment 1 (hoed check) were higher than nine herbicide treatments (20, 16, 3, 19, 17, 18, 24, 11, 14) while treatment 22 (EPTC + simazine, G) was higher than treatments 20 and 16.

The delayed application of diphenamid did not show any adverse effects on size or development of runner plants.

Weights of Mother (original) Plants (Table 2)

Mother plants from treatment 1 (hoed check) had greater weights than plants from thirteen treatments (20, 24, 5, 8, 3, 18, 19, 16, 15, 11, 7, 14 and 4).

Treatment 23 had greater weights of mother plants than treatments 20 and 24 while treatment 6 was only greater than treatment 20.

The foregoing would indicate varying degrees of injury from herbicide treatments.

Weight of All Weeds (Table 3)

The weights of weeds (grasses and broadleaf weeds) in treatments 23, 6 and 15 (EPTC + simazine, wp; diphenamid, 6 lb/A ai applied 5 weeks after setting; and diphenamid, 12 lb/A ai applied 2 weeks after setting) were significantly less than in treatments:

- 20 - solan + solan
- 16 - dinoben, ec
- 19 - swep + swep

As a means of further comparison, treatments 6 and 23 (above) also gave better weed control than treatment 9 (R-1607 + simazine). Similarly, treatment 23 was better than treatment 3 (2,4-DEP + diphenamid) in total weed control.

Weights of Grassy Weeds (Table 3)

The six treatments which gave better grassy weed control (by fresh weight) than treatment 19 (swep + swep) were:

- 23 - EPTC + simazine, wp
- 6 - diphenamid, 6 lb/A ai, 5 weeks after setting
- 15 - diphenamid, 12 lb/A ai, 2 weeks after setting
- 22 - EPTC + simazine, G
- 24 - SD-7961
- 11 - DCPA + 2,4-DEP

Treatments 23, 6, 15 and 22 also gave better grassy weed control than treatments 16 (dinoben, ec) and 20 (solan + solan).

Treatments 23 and 6 were also better than treatment 9 (R-1607 + simazine) while treatment 23 gave better control of grassy weeds than treatment 3 (2,4-DEP + diphenamid).

Weight of Broadleaf Weeds (Table 3)

No significant differences were found among treatment means for weight of annual broadleaf weeds.

Barnyardgrass Control (Table 3)

Barnyardgrass was the major weed that was not controlled. Barnyardgrass accounted for 87% of the total weed weight and 96% of the total weight of grasses.

Numbers

Treatments 6 and 23 (diphenamid 6 lb/A ai applied 5 weeks after setting and EPTC + simazine, wp) gave better control of barnyardgrass as measured by numbers of plants than treatments:

- 20 - solan + solan
- 19 - swep + swep
- 16 - dinoben, ec
- 3 - 2,4-DEP + diphenamid
- 9 - R-1607 + simazine
- 8 - tillam + simazine
- 17 - dinoben, G

Table 3. Effect of several herbicide treatments on weed control per plot (210 square feet) in a planting of Tennessee Beauty Strawberry plants.

No.	Treatment Herbicides applied	Pounds of Weeds			Barnyardgrass	
		Grass	Broad- Leaf	Total	Number	Weight lbs.
1	Hoed Check	0.1 a	0.3 a	0.4 a	44 a	0.1 a
2	DCPA + diphenamid	24.3 ae	2.2 a	26.5 ad	2152 ae	23.3 ad
3	2,4-DEP + diphenamid	49.4 be	2.9 a	52.3 bd	6514 dg	46.6 ad
4	Tillam + diphenamid	37.2 ae	8.7 a	45.9 ad	6204 bf	35.3 ad
5	R-1607 + diphenamid	32.7 ae	1.9 a	44.6 ad	3220 bf	30.7 ad
6	Diphenamid, 5 wks. post-setting	2.8 ab	0.6 a	3.4 ab	280 ab	2.8 ab
7	Swap + diphenamid	17.9 ae	0.2 a	18.1 ad	1391 ad	17.8 ad
8	Tillam + simazine	45.3 ae	2.6 a	47.9 ad	5618 cg	45.0 ad
9	R-1607 + simazine	51.4 ce	3.0 a	54.4 cd	5582 cg	50.1 bd
11	DCPA + 2,4-DEP	16.3 ad	6.4 a	22.7 ad	1531 ad	15.6 ad
12	Diphenamid + 2,4-DEP diphenamid	25.7 ae	4.1 a	29.8 ad	2188 ad	23.9 ad
13	Diphenamid, 2 wks. post-setting	25.1 ae	9.7 a	34.8 ad	3220 bf	23.3 ad
14	Diphenamid + simazine	34.6 ae	7.3 a	41.9 ad	3150 ae	33.7 ad
15	Diphenamid, 12 lb/A post-setting	8.5 ac	3.0 a	11.5 ac	858 ac	8.4 ab
16	Dinoben, ec	62.5 de	0.9 a	63.4 d	8138 eg	61.8 d
17	Dinoben, G	35.0 ae	2.8 a	37.8 ad	5338 cg	34.5 ad
18	Dinoben, ec + diphenamid	26.9 ae	1.0 a	27.9 ad	3815 bf	26.4 ad
19	Swap + swap	63.1 e	0.2 a	63.3 d	7822 fg	62.8 d
20	Solan + solan	61.6 de	3.6 a	65.2 d	11550 g	56.3 cd
22	EPTC + simazine, G	11.1 ac	7.4 a	18.5 ad	1592 ad	10.4 ac
23	EPTC + simazine, wp	2.0 a	0.1 a	2.1 a	324 ab	2.0 a
24	SD-7961	16.1 ad	0.3 a	16.4 ad	1628 ad	14.0 ac
		D=46.4	D=14.9	D=49.9		D=29.5

Treatment averages followed by the same letter are not significantly different from each other using Tukey's test of "All Comparisons Among Means" as described by Snedecor.

¹ Before statistical analyses, the number of barnyardgrass plants were transformed by $x = \sqrt{y + 1}$, where y is the original count.

Numbers (Continued)

Treatment 15 (diphenamid, 12 lb/A ai applied 2 weeks after setting) gave better control than treatments:

- 20 - solan + solan
- 19 - swep + swep
- 16 - dinoben, ec
- 3 - 2,4-DEP + diphenamid

Five treatments: 7, 22, 11, 24 and 12 (swep + diphenamid; EPIC + simazine, G; DCPA + 2,4-DEP; SD-7961; and diphenamid + diphenamid, two 3-pound applications 2 and 5 weeks after setting) were better than treatments:

- 20 - solan + solan
- 19 - swep + swep
- 16 - dinoben, ec

Two treatments: 2 and 14 (DCPA + diphenamid and diphenamid + simazine) were better than treatments 20 and 19.

Four treatments: 13, 5, 18 and 4 (diphenamid, 6 lb/A ai applied 2 weeks after setting; R-1607 + diphenamid; dinoben, ec + diphenamid; and tillam + diphenamid) gave better control of barnyardgrass (by numbers) than treatment 20 (solan + solan).

Weights

Treatment 23 (EPIC + simazine, wp) gave better control of barnyardgrass (by weight) than treatments:

- 19 - swep + swep
- 16 - dinoben, ec
- 20 - solan + solan
- 9 - R-1607 + simazine

Two treatments: 6 and 15 (diphenamid, 6 lb/A ai applied 5 weeks after setting and diphenamid, 12 lb/A ai applied 2 weeks after setting) gave better control than:

- 19 - swep + swep
- 16 - dinoben, ec
- 20 - solan + solan

Two treatments: 22 and 24 (EPIC + simazine, G and SD-7961) gave better control of barnyardgrass (by weight) than treatments:

- 19 - swep + swep
- 16 - dinoben, ec

SUMMARY

The herbicide treatments which gave the best weed control with the least injury to Tennessee Beauty strawberry plants or runners were:

- 6 - Diphenamid, wp (6 lb/A ai). Topical application 5 weeks after plants were set.
- 23 - EPTC, G + simazine, wp (5 + 1 lb/A ai). EPTC was soil incorporated within 15 minutes after application. Simazine was then applied as a spray. Both herbicides applied 5 weeks after plants were set.
- 22 - EPTC, G + simazine, G (5 + 1 lb/A ai). Both granular herbicides were broadcast on surface and soil incorporated within 15 minutes. Both herbicides applied 5 weeks after plants were set.

The poorest herbicide treatments which caused some plant injury and lacked weed control were treatments:

- 20 - Solan + solan, ec (4 + 4 lb/A ai). Topical application 5 and 9 weeks after plants were set.
- 19 - Swep + swep, G (6 + 6 lb/A ai). Broadcast application 2 and 9 weeks after plants were set. Swep granules were not soil incorporated.
- 16 - Dinoben, ec (4 lb/A ai). Topical application 2 weeks after plants were set.
- 3 - 2,4-DEP, ec + diphenamid, wp (4 + 3 lb/A ai). Topical application 2 weeks after plants were set.
- 18 - Dinoben, ec + diphenamid, wp (4 + 3 lb/A ai). Topical application 2 weeks after plants were set.

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THE RELATIONSHIP OF WATER TO THE EFFECTIVENESS OF SEVERAL HERBICIDES ON WEED CONTROL IN STRAWBERRIES DURING 1963

C. A. Langer¹

Introduction

Efficient, consistent, and reliable weed control in growing strawberries could be a key factor in the development of this fruit into a major crop in New Hampshire as well as other areas. This research was designed primarily to evaluate several herbicides for their ability to control weeds, but due to unusual drought conditions, it became apparent that the investigation should be revamped somewhat to also include water relationship to herbicide activity.

Procedure

Three weed control plots were established, each on a different farm. Three rows were chosen on each farm for treatment. Each herbicide treatment was replicated three times. The plants were all set on April 5 on Farm No. 1, April 7 on Farm No. 2, and April 10 on Farm No. 3. Soils of Farm No. 1 and Farm No. 2 were of the loamy sand type with some stones present. Soil of Farm No. 3 was a sandy loam free from stones. The varieties Catskill on Farm No. 1, Vesper, Midland and Early Dawn on Farm No. 2, and Sparkle on Farm No. 3 were used in weed control trials. Replicated plots were each 1/100 of an acre in size. The plots at each farm were carefully cultivated and hoed in each case just prior to application of herbicides, regardless of the date they were applied. Experimental plots, as well as the rest of the strawberry planting, on Farm No. 1 received one inch of water by irrigation within three days after herbicide applications. No more than 1/4 inch of water fell on the plots of Farm No. 2 or Farm No. 3 within 28 days after herbicide applications. Soil moisture at the time of herbicide applications appeared to be uniform on all plots on all farms. In each case, soil was moist, freshly cultivated and hoed, and free from germinated weeds as far as could be detected from visual observation. Wettable powders and liquids were applied with a continuous pressure (25 pounds) knapsack sprayer with a hand boom fitted with two flat fan type nozzles. Each 1/100-acre plot received one gallon of spray applied uniformly.

The weed plots on Farm No. 1 were cultivated and hoed on July 11, and the second application of herbicide applied on July 12. After nine weeks, or on August 7, culture of Farm No. 2 plots was changed to clean cultivation. Farm No. 3 plots were established on July 12 and reverted to clean cultivation on September 15.

Results and Discussion

Farm No. 1

All four treatments showed excellent weed control after application of each herbicide. On July 11, when plots were all hoed and cultivated, only

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Table I. The Relationship of Water to the Effectiveness of Several Herbicides on Weed Control in Strawberries during 1963.

No.:	Treatment and Formulation	Lbs/A		Daughter Plant Production and/or Injury ^{5/}					Weed Control*			
		1st Appl.	2nd Appl.	7/11	8/6	9/15	10/15	6/20	7/11	8/6	9/15	10/15
<u>Farm No. 1^{1/}</u>												
1.	Cultivated Check	-	-	5	5	5	5	0	10	7.5	9	8.5
2.	Dacthal 75% wp	9	9	5	5	5	5	9.5	10	9	8.5	8
3.	Dinoben (Amchem 63-102)	6	6	4.5	4.5	4	4	10	10	10	9	9
4.	Diphenamid 80% wp	6	6	5	5	5	5	10	10	10	9	9
5.	Diphenamid 50% wp	6	6	5	6	6	6	10	10	10	9	9
<u>Farm No. 2^{2/}</u>												
1.	Cultivated Check	-	-	5	5	5	5	0	0	9	9	8
2.	Dacthal 75% wp	9	-	5	5	5	5	0	0	9	9	8
3.	Dinoben (Amchem 63-102)	6	-	5	5	5	5	0	0	9	9	8
4.	Diphenamid 80% wp	6	-	5	5	5	5	0	0	9	9	9.5
5.	Diphenamid 50% wp	6	-	5	5	5	5	0	0	9	9	9.5
<u>Farm No. 3^{2/}</u>												
1.	Cultivated Check	-	-	5	5	5	5	8	10	7.5	8.5	8
2.	Dacthal 75% wp	-	9	5	5	5	4.5	8	10	0	0	8
3.	Dinoben (Amchem 63-102)	-	6	5	5	5	4.5	8	10	0	0	8
4.	Diphenamid 80% wp	-	6	5	5	5	4.5	8	10	0	0	9
5.	Diphenamid 50% wp	-	6	5	5	5	4.5	8	10	0	0	9

^{1/} One inch of water applied within three days of treatment.

^{2/} No more than 1/4" water fell within 28 days of treatment.

^{3/} Clean cultivated after 7/11 date.

^{4/} Clean cultivation through 7/11, then treated, but by 9/15 no weed control was evident. Plots were then clean cultivated.

^{5/} 5 = similar to cultivated check; 0 = 50% less than check; 10 = 50% better than check, by estimation.

* 0 = no weed control; 10 = near perfect; 7.5 = commercial weed control.

very small and limited numbers of weeds were present. The first application of all herbicide materials was effective for ten weeks. The second application was successful in holding back new weeds, but it was apparent that a few germinated weeds passed undetected during the July 11 cultivation and hoeing. Runner delay was experienced only with Dinoben (Amchem 63-102). There was a definite increased vigor from Diphenamid 50% wettable powder, as indicated by Table I, weed control data for Farms 2 and 3, under 10/15 inspection date.

Farm No. 2

All four treatments failed completely. At the end of nine weeks, clean cultivation was started in treated plots. At the October 15 inspection of the plots, it was very evident that both Diphenamid treatments had given definite weed control after mid-September rains. There was no difference in growth or health of plants between cultivated check or treated plots.

Farm No. 3

All four treatments applied on July 12 completely failed to control weeds during the nine weeks following application. Plots were reverted to clean cultivation on September 16. At the October 15 inspection of plots, it was again evident that both Diphenamid treatments had given definite weed control following adequate moisture in mid-September. There was a slight retardation of all runner plants in all treated plots compared to cultivated check. This was noted after spray plots were reverted to cultivation. The retardation of runner plants could be attributed to weed infestation in the sprayed plots compared to the more weed-free cultivated check plots.

Summary

It would be impractical to draw any conclusions from one year's trial, but a few results have emerged:

1. It was evident this year that a definite benefit was derived from adding water within three days after each application of a pre-emergence herbicide.
2. Results this year with the herbicide chemicals used substantiated findings of other researchers(1) that the weed control life of these materials is approximately nine weeks during desirable conditions for their activity.
3. Observations indicate that Diphenamid remains somewhat inactive and then becomes an active weed killer when moisture is added, even though light cultivation has taken place during the interim.

Literature Cited

1. Stadelbacher, G. J. and J. D. Riggleman. 1963. Weed Control in Newly Established Strawberry Plantings, Proc. of N.E. Weed Control Conference, Vol. 17: 192-193.

HERBICIDE EFFECTS ON NEWLY ESTABLISHED STRAWBERRY PLANTS AND SUBSEQUENT FRUIT

PRODUCTION 1/G. J. Stadelbacher, J. D. Riggelman and Dorothy A. White 2/

Introduction

The ultimate goal of the herbicide research worker with strawberries is to find a chemical that will control weeds all season long with one or at most two applications, will not injure the strawberry plant, will not be translocated to the fruit, and will be economical to use and easy to apply. This goal seemed close to reality with the recent introduction of several herbicides that had long residue capabilities. Since the strawberry is a perennial, it is important to know what effect if any the herbicide is having on fruit production the following year. This is in addition to possible effects on vegetative growth the year of application.

Objectives

To test for the above effects a program was established in Maryland whereby new plantings would be started each year. The most promising herbicides would be tested. Their effectiveness in controlling grasses and broadleaves as well as such phytotoxic symptoms as plant stunting, daughter plant production, leaf symptoms, and root inhibition on runner plants would be recorded. In addition, possible effects on fruit production were to be determined. Size of fruit as well as total weight of the berries was to be recorded since marketable yield is determined by fruit size. Fruit size as well as numbers is a critical factor with the long residue herbicides, since the condition of the plant during the flower initiation stage in early fall and flower development in late fall has a very important bearing on the number and size of fruits the following season.

Materials and Methods

On April 5, 1962, a planting of Pocahontas was established in Lakeland loamy sand at the Vegetable Research Farm at Salisbury, Maryland. The experiment was set up as a randomized complete block, 3 row plots (only center row used for records), replicated 4 times with 14 plants per row. The plants were spaced 26 inches apart in the row. Rows were spaced 52 inches apart. All plots received the regular fertilizer, nemagon, and pesticide treatments used in the certified plant program on the Research Farm. Herbicides used as well as rates and dates of application are given on Table 1. Herbicide effects as measured by injury rating, weed control, daughter plant production and yield are also

1/ Scientific Article No. A 1098, Contribution No. 3528 of the Maryland Agricultural Experiment Station, Department of Horticulture.

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included in Table 1. A chemical check (Sesone) as well as a cultivated check was included. On November 30, 1962, all plants including the cultivated check received Sesone 90 S at 2.7 lbs AI/A plus CIPC at 2.0 lbs AI/A for winter weed control.

Fruit from the center row of each plot was harvested and weighed. One quart of berries was randomly selected from each replication for fruit size measurements.

After harvest the leaves were removed from the plants of all plots with a rotary mower. The rows were then cut down to 8 inches in width and sidedressed with Nemagon plus fertilizer. Plant stand was reduced by crossing the rows at 45 degrees with a spiked tooth harrow. On June 20, 1963, the herbicides listed in Table 2 were applied to the renovated field. DCPA 75W at 6.0 pounds AI/A plus Diphenamid 80W at 3.0 pounds AI/A was substituted for the Trifluralin treatment. A 0.25 inch rain fell just prior to the herbicide application and a 0.30 inch rain followed soon after the application. A severe drought followed.

On April 2, 1963, another planting of Pocahontas was established. This planting included plots which received the same cultural treatment as the 1962 planting plus another block for testing various rates of a selected number of herbicides as applied with an exponential sprayer. The treatments, rate and time of application, phytotoxicity, weed control and daughter plant production are given in Table 3. Table 4 contains the treatments, date and rate of application, date observations were made, phytotoxicity and rates necessary for 100% and 90% weed control for the exponential plots. The rows in the exponential plot were of sufficient length to provide 4 reductions in herbicide concentration. Each reduction was 1/2 of the preceding concentration. Methods used to record plant responses to the herbicides are given as footnotes at the bottom of each table.

Results and Discussion

The vegetative responses of the 1962 planting were reported in detail in Volume 17 of the Northeastern Weed Control Conference Proceedings. They are included in less detail in Table 1 to enable the reader to evaluate both vegetative and fruiting responses of the strawberry to the various herbicides. Results in Table 1 indicate that there were no real differences in weed control among Trifluralin, DCPA, Diphenamid and DMPA. Because of the severe drought there were no differences in length of control. Trifluralin and Diphenamid stunted early plant production. Diphenamid applied immediately after planting had a severe stunting effect as indicated by 85 plants versus 1,690 for the cultivated check. The stunting by Diphenamid did not occur after the 7/25 application. Results indicated that strawberries growing in light sandy soil would not tolerate Diphenamid shortly after transplanting. The same results also showed that later applications were not harmful. Phytotoxicity of Diphenamid was expressed by reduced plant growth. Trifluralin did not reduce plant production nearly as much as Diphenamid but it had a restricting effect all season. This is illustrated by the low plant count at the end of the season. DMPA showed only slight inhibitory effects on plant production. It was the only chemical that reduced fruit production when compared on a plant population basis. Trifluralin, Diphenamid and DMPA significantly decreased the fruit yield. The

decrease caused by Trifluralin and Diphenamid was due to a lower plant population whereas the reduction from DMPA was due to less yield per plant. There were no differences among treatments in fruit size. There was no daughter plant root inhibition from any of the treatments. Table 1 indicates that DCPA was the best herbicide in 1962.

Results of the herbicide treatments after renovation are presented in Table 2. A severe drought immediately after renovation nullified most of the measurable effects recorded as plant injury. DMPA was the one exception. It produced definite necrosis of the leaves. The low readings which indicate injury is in reality plant loss due to dry weather. This is illustrated by the large amount of injury recorded for the cultivated check. No explanation can be given for the superior plant stands of most of the herbicide treatments since all were handled the same culturally. The DCPA plus Diphenamid gave fair results despite adverse climatic conditions.

Results for the replicated 1963 planting are given in Table 3. The same thing occurred in 1963 with Diphenamid as in 1962. Even though application was delayed 20 days after planting, considerable stunting occurred. This did not happen with the later application. The plants recovered from the early application but total plant production was reduced. The early treatment of DCPA followed by a midseason application of Diphenamid was the most promising treatment for commercial usage. R 1607 looked promising in exponential work in 1962 but it was a complete failure in 1963. It broke down too rapidly as a surface application and it was too toxic when incorporated. Surface application and incorporation indicated that concentrations of R 1607 necessary to control weeds would either injure or kill strawberry plants in loamy sand. The data for R 1607 in Table 3 is deceiving because the plot had to be treated like a cultivated check shortly after the April 2 treatment due to no residue control, consequently the 6/10 and 6/20 weed control ratings were not included in the Table. The 5/27 through 6/20 weed control data for the single late application of Diphenamid was also left out since that period of the plot was also handled the same as the cultivated check. DCPA at 8 pounds immediately after planting followed by a second 8-pound application 15 weeks later was the best treatment that has Food and Drug Administration clearance. The differences in daughter plant production were not significant at the 5 per cent level.

Results from the exponential applications are presented in Table 4. The maximum rate that the plants would tolerate, the level at which no injury was observed as well as rate necessary for 100 per cent and 90 per cent weed control on Lakeland loamy sand are listed. Diphenamid injured the strawberry plants in all applications up to and including the one made 29 days after transplanting. Applications 42 days after planting and later did not injure the berry plants at levels well above the rates needed for weed control. R 1607 was not satisfactory as an incorporated treatment before planting or as a surface application immediately after planting. The incorporated treatment injured the berries at levels below the rate required for satisfactory weed control. The surface application produced similar results plus the fact that weed control failed within 2 weeks after application. R 4572 produced similar results.

Table 1. Effects of Herbicides on Freedom from Injury, Weed Control, and Daughter Plant Production in 1962 and Fruit Production in 1963 When Applied to Pocahontas Strawberries Planted on April 5, 1962, in Lakeland Loamy Sand and Treated as Indicated.^{1/}

Treatment	Lbs. AI/A	Dates Applied 1962	Inj. Rating		Weed Control		Daughter Plants Per Acre (Thous.)		Yield Qts/A 1963 ^{5/}
			1962 ^{3/} 5/28	1962 ^{3/} 6/15	1962 ^{4/} 5/28	1962 ^{4/} 8/17	1962 5/28	1962 8/30	
1. Cultivated check ^{2/}			10.0	10.0	10.0	6.3	1,690	160,000	10,022 A
2. Sesone 90S	2.7 + 2.7	5/14 + 7/25	9.5	9.8	9.8	7.8	1,520	165,000	10,686 A
3. Trifluralin 5G + ^{4E}	5.6 + 4.0	4/5 + 7/2	9.0	8.8	9.8	10.0	507	92,200	6,204 C
4. DCPA 75W	9.0 + 9.0	4/5 + 7/2	9.5	9.5	9.0	8.5	1,158	172,000	10,334 A
5. Diphenamid	4.0 + 4.0	4/5 + 7/25	6.5	6.0	10.0	9.0	85	90,500	7,470 BC
6. DMPA 3E	10.0 + 10.0	4/5 + 7/2	9.3	9.0	9.3	7.0	2,125	162,500	8,798 AB

^{1/} Figures are averages of four replications.

^{2/} Cultivated and hoed 4/19, 5/4, 6/5, 6/19, 6/29, 7/2, 7/25.

^{3/} Rated 1-10 where 1 = death and 10 = no injury.

^{4/} Rated 1-10 where 7 = lowest value for acceptable commercial control and 10 = nearly perfect control.

^{5/} LSD at 5% level 2,154 qts. per acre-A, B, C, indicate significant differences.

Table 2. The 1963 Herbicide Ratings for Pocahontas Strawberries Planted in 1962 and Renovated in June 1963 on Freedom from Injury and Control of Weeds.^{1/}

Treatment	lbs AI/A	Injury ^{2/} _{9/10} ^{3/}		Control ^{4/} _{9/10}	
		B1 ^{5/}	G ^{6/}	B1 ^{5/}	G ^{6/}
Cult Check		3.5		0	8.8
Sesone 90S	2.7	5.5		0	8.3
DCPA 75W plus	6.0 +	6.3		10.0	5.0
Diphenamid 80W	3.0				
DCPA 75W	8.0	7.5		6.5	5.5
Diphenamid 80W	4.0	5.8		9.0	4.5
DMPA 3E	10.0	3.5		0	8.3

^{1/} Table 1 field renovated after harvest and treated on June 20, 1963.

^{2/} Rated 1-10 where 1 = death and 10 = no injury.

^{3/} Measure of plants ability to stand extreme drought after renovation with the exception of DMPA.

^{4/} Rated 1-10 where 7 = lowest value for acceptable commercial control and 10 = nearly perfect control.

^{5/} Broadleaf weeds.

^{6/} Grasses.

Table 3. Effects of Herbicides on Freedom from Injury, Weed Control and Daughter Plant Production When Applied to Pocahontas Strawberries Planted on April 2, 1963, in Lakeland Loamy Sand and Treated as Indicated.^{1/}

Compound	Lbs AI/A		Freedom from Injury ^{2/}				Control of Weeds ^{3/}					Daughter Pl (Thou/A)		
	4/2	7/25	5/27	6/10	6/20	9/10	5/27	6/10	6/20	9/10	7/31	9/10		
		on						Bl	G	Bl	G			
Cult Check			10.0	9.8	10.0	10.0	4.8	10.0	10.0	7.8	7.8	4.3	48.5	58
DCPA 75W	8	8	9.3	10.0	10.0	8.5	9.0	6.8	10.0	5.5	10.0	9.8	37.6	41
DCPA 75W - Diphenamid 80W	8	4	9.5	10.0	10.0	8.0	9.0	7.3	10.0	5.0	10.0	9.3	47.1	50
Diphenamid 80W	4	4	8.0	8.3	8.0	7.8	10.0	7.8	7.8	6.5	5.0	8.0	29.1	38
Diphenamid 80W		4	10.0	10.0	10.0	9.8	-	-	-	-	-	8.8	49.7	68
R 1607 6E - R 1607 10G ^{7/}	6	6	9.8	10.0	10.0	7.8	5.8	-	-	-	-	-	40.3	46
Significance at 5% level												NS		

^{1/} Figures are averages of four replications.

^{2/} Rated 1-10 where 1 equals death and 10 equals no injury.

^{3/} Rated 1-10 where 7 equals lowest value for acceptable commercial control and 10 equals nearly perfect control.

^{4/} Applied April 22 rather than April 2.

^{5/} Bl is Broadleaf weed control.

^{6/} G is grass control.

^{7/} R 1607 10G incorporated at the 7/25 date.

Table 4. Effects of Herbicides Applied with an Exponential Sprayer on Newly Established Pocahontas Strawberries and Native Weeds Growing in Lakeland Loamy Sand in 1963.

Treatment <u>1/</u>	High Rate	Obsv Date	Strawberries		Native Weeds		
			A <u>2/</u>	B <u>3/</u>	C <u>4/</u>	D <u>5/</u>	
Diphenamid							
AP	80W	16	6/10 9/10	16 16	S 3	7 NC	4 16
14 days	80W	16	6/10 9/10	13 16	3 3	4 NC	3 10
20 days	80W	12	6/10 9/10	12 12	5 6	5 NC	4 12
29 days	80W	16	6/10 9/10	16 16	8 5	5 NC	2 16
42 days	80W	16	6/10 9/10	16 16	5 8	2 16	- 10
62 days	80W	16	6/10 9/10	16 16	16 8	2 6	- 4
90 days	80W	16	6/10 9/10	- 16	- 8	- 5	- 2
R 1607							
inc PP	6E	14	6/10 9/10	4 -	S -	2 12	- 9
AP	6E	14	6/10 9/10	14 -	9 -	NC NC	14 NC
R 4572							
inc 2 wks	6E	14	6/10 9/10	14 -	S -	NC NC	14 NC
2 wks	6E	14	6/10 9/10	14 -	6 -	12 NC	9 NC

1/ Herbicides applied incorporated pre-planting (inc PP); incorporated after planting (inc 2 wks); applied to the surface immediately after planting (AP); or applied to the surface at a specific number of days after planting (14 days, 20 days etc.).

2/ The highest rate as lbs AI/A the plant would tolerate and still live.

3/ The rate as lbs AI/A where the plant showed no injury symptoms. "S" indicated that the crop was sensitive at the lowest rate applied.

4/ Rate as lbs AI/A necessary for 100% control. "NC" indicates weed control was

Summary

1. DCPA at 9 pound AI/A immediately after planting and 3 months later gave good weed control without reducing daughter plant production.
2. DCPA at 8 pounds AI/A in 1963 did not give satisfactory broadleaf weed control.
3. Trifluralin injured berry plants too much at rates necessary for weed control.
4. Diphenamid applications at or near planting injured strawberry plants growing in Lakeland loamy sand in 1962 as well as in 1963.
5. Results indicate that Diphenamid can be safely applied 42 days after planting and will give good weed control.
6. DMPA reduced fruit production and produced enough injury in the after harvest treatment to eliminate it in future work.
7. None of the herbicides, except DMPA, tested to date have affected fruit production.
8. None of the herbicides tested inhibited daughter plant root growth similar to that which occasionally occurs with Sesone.
9. R 1607 and R 4572 were too phytotoxic for use with strawberries.

PRELIMINARY STUDIES OF THE EFFECTS OF PHOTOPERIOD, TEMPERATURE, AND
 LIGHT INTENSITY ON THE GROWTH OF POLYGONUM PENNSYLVANICUM,
P. PERSICARIA, AND P. SCABRUM¹

J. B. Regan and R. S. Bell²

The Northeastern Weed Control Committee (NE-42), studying weed life cycles as related to weed control, is currently investigating ladythumb (P. persicaria) and Pennsylvania smartweed (P. pennsylvanicum) in cooperation with the Rhode Island Agricultural Experiment Station. A white-flowered smartweed was found growing in association with these in Rhode Island, and is included in the studies. It was identified as Polygonum scabrum Moench. The flowers of smartweeds are borne in compact spikes and occur in subgroups within the inflorescence. Flowering is indeterminate within the clusters and continues for four to six weeks. Flowering for several weeks also means a long period of seed ripening.

Few studies have been made concerning the effect of photoperiod on weeds. Allard and Garner (1) reported that Pennsylvania smartweed flowered under short and long days, but flowering was hastened with increased length of day. Observations on the other smartweeds were not found in the literature.

Effect of light intensity and photoperiod on growth of Polygonum scabrum
 (Test #1)

Two growth chambers built after a design by DeRemer and Smith (2) were used in these tests. Seedlings were started in small flats of soil and transplanted into 3" pots two weeks after seeding. The seedlings were exposed to a 12-hour day for about fourteen days previous to being transplanted. The seedlings were divided into three lots in each chamber: (1) placed sufficiently near the lights to get an exposure of 2500 foot candles; (2) placed on the floor of the chamber at 1200 fc; (3) a third set was shaded with a double layer of green nylon screen allowing 450 fc. Two photoperiods were used - a 12 and an 18 hour day, respectively. Four harvests were made between October 30 and December 20. The plants were fertilized with a complete liquid fertilizer. The last set was repotted into 4" pots one month before harvest. Eight plants were used in each replicate. A 75°F temperature was maintained during the light period, and 65°F during the dark period. A summary of the last harvest is shown in Table 1.

Flower buds appeared nine days after starting the treatment in the 12-hour chamber and fifteen days after beginning the long-day test. Light intensity did not influence the time of bud appearance.

Plants under the high light intensity were shorter and exhibited an ascending rather than upright growth. The low dry weight per plant under the long day and lower light intensities reflect the effect of six extra hours at 75°F which apparently upset the balance between photosynthesis and respiration. The plants grown with lower light intensities looked more normal, being greener and more upright. The shaded plants with the 12-hour day were shorter and less vigorous than the shaded plants with the 18-hour photoperiod. The shaded plants showed a sparse root development compared to the unshaded ones.

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Table 1. Effect of photoperiod and light intensity on P. scabrum.

Light intensity	Number leaves	Number flower clusters	Number branches	Dry wt gm/plant	Percent H ₂ O
12-hour photoperiod					
2400 fc	60	43	8	18.1	73
1200 fc	47	36	8	17.2	73
450 fc	38	16	3	16.0	79
18-hour photoperiod					
2400 fc	68	30	7	10.9	73
1200 fc	58	18	4	4.2	79
450 fc	38	11	3	2.3	79

Table 2. Effect of photoperiod on development of P. persicaria.

	Photoperiod	
	12-hour	18-hour
Number leaves	63	130
Number flower clusters	25	18
Days to budding	23	50
Number branches	7	5
Dry wt, gm/plant	2.5	4.3
Percent moisture	73	76

Table 3. Effect of temperature variation on three species of Polygonum grown under 15-hour photoperiod.

	Number leaves	Number flower clusters	Days to budding	Number branches	Dry wt gm/plant	Percent H ₂ O
<u>P. pensylvanicum</u>						
65-75°F	41	10	36	3	5.7	70
55-65°F	31	7	55	2	4.3	73
<u>P. persicaria</u>						
65-75°F	67	24	24	7	2.2	78
55-65°F	48	32	33	6	2.9	78
<u>P. scabrum</u>						
65-75°F	48	38	24	4	4.5	66
55-65°F	55	20	43	3	2.6	74

P. persicaria
(Test #2)

Seedlings of Ladysthumb were grown under the same photoperiod and temperature conditions as Test 1. The seedlings were started with an 18-hour light period. The plants were placed on the floor of the chambers and received the medium light intensity. The data are shown in Table 2.

Ladysthumb in good light tends to grow prostrate with ascending tips. Ladysthumb had 130 leaves under long photoperiod, and less than half as many with the shorter one. The trend for more flower clusters and branches was noted. The 'long-day' plants were heavier than the 'short-day' plants, weighing 4.3 and 2.5 grams per plant, respectively.

The first flowers appeared on the short-day plants 23 days after the treatment, but were delayed for 50 days under the long photoperiod.

Effect of temperature on 3 species of Polygonum
(Test #3)

In the next test both chambers were set for a 15-hour photoperiod. One chamber was maintained at 75°F during the light period and 65°F during the dark one. The second chamber was maintained 10 degrees cooler. The seedlings were started under a 24-hour photoperiod.

Three species of Polygonum were grown: P. pensylvanicum, P. persicaria and P. scabrum. With the 75-65°F range, flower buds appeared after 24 days on persicaria and scabrum, and after 36 days on pensylvanicum. Under the influence of the cooler 65-55°F range, the show of buds was delayed 19 more days for pensylvanicum and scabrum, but only 9 days for persicaria. See Table 3.

Three flats of P. persicaria seedlings were placed under continuous illumination on November 13, 1962. Flower buds were apparent on these plants 50 days later, the same as on the plants in the 18-hour chamber.

Five-hour photoperiods
(Test #4)

To test whether the effect of light is due to the length of the photoperiod or total amount of light received in a 24-hour period, one chamber was set for three 5-hour light periods alternating with three 3-hour dark periods. The second chamber was adjusted to a 15-hour day and a 9-hour period of darkness. The daily temperature fluctuation was 70±2°F. The results are shown in Table 4. The three species of Polygonum were used. The seedlings were started under the photoperiod in which they were to be tested.

Plants with the interrupted day averaged about an inch taller than those exposed to 15 hours of light. Otherwise there was very little difference in growth of either P. persicaria or P. pensylvanicum. Buds were apparent at the end of 49 days on P. pensylvanicum in each treatment. The 5-hour day delayed the appearance of flower buds on the P. scabrum plants by 27 days, but by only 4 days for P. persicaria.

Table 4. Comparison of a 15-hour photoperiod versus three interrupted 5-hour periods per day with three smartweed species.

	Number leaves	Number flower clusters	Days to budding	Number branches	Dry wt gm/plant	Percent H ₂ O
<u>P. pensylvanicum</u>						
15-hour	72	3	49	5	5.8	80
5-hour	72	4	49	4	5.6	79
<u>P. persicaria</u>						
15-hour	101	38	33	5	6.3	76
5-hour	92	41	37	5	6.0	76
<u>P. scabrum</u>						
15-hour	87	53	31	6	9.4	66
5-hour	90	22	58	5	8.9	76

Field observations

P. persicaria grown in full sun without competition spreads out flat against the ground, and its many stems radiate in all directions, forming a circular mass about 12-18 inches across. When grown with a competing plant such as potatoes, P. persicaria is usually single-stemmed and grows upright toward the light.

P. pensylvanicum grows upright to about three feet and is very bushy and well-branched without competition, but may become single-stemmed and vine-looking when grown with a strongly competing crop. P. scabrum without competition reaches about one-third the size of Pennsylvania smartweed. It also becomes elongated when shaded by a competing plant.

Planting of these three species of smartweed were made at 10-day intervals between June 7 and July 18, and the days for development of visual flower buds were noted. The average dry weight in pounds per plant was determined. These are shown in Table 5.

Table 5. Length of time to budding and dry weight per plant. (Field test)

Planting date	<u>P. pensylvanicum</u>		<u>P. persicaria</u>		<u>P. scabrum</u>	
	Days to full bud	lb/plant dry wt	Days to full bud	lb/plant dry wt	Days to full bud	lb/plant dry wt
June 7	55	0.230	51	0.055	51	0.195
June 17	54	0.227	45	0.027	45	0.072
June 27	40	0.030	33	0.027	40	0.040
July 8	45	0.022	33	0.012	33	0.022
July 18	43	0.010	35	0.010	31	0.010

smaller plants with the later planting dates. However, the days to budding did not vary appreciably from the June 27 to the July 18 plantings. When photoperiod and temperature are favorable, flower bud differentiation occurs on progressively smaller plants as the season progresses from early to late summer. Ladysthumb plants an inch high and in full bloom are sometimes found in our greenhouses during the winter months.

Discussion and summary

In the first test with Polygonum scabrum, the chambers were not ready so the seedlings were grown for two weeks in a greenhouse with a natural photoperiod of 12 hours. Flower bud initiation took place within 14 days as they became visible 9 days after placing the plants in the 'short-day' chamber. In the test comparing a 15-hour light period to three 5-hour light periods, the seedlings were started on continuous light, 31 days were required for buds to show after the seedlings were placed under treatment. Those under the interrupted day required 58 days. Again in 1963 P. scabrum was germinated and held for 14 days in a greenhouse under a natural day length of 12 hours before starting the differential treatments. About 50% of these plants developed visible flower buds 11 days after starting the test. Buds became apparent on the rest 40 days after treatment. This indicates that conditions for flower bud development are initiated within a few days after exposure to the short photoperiod.

Although the tests are incomplete at this time, it appears that bud formation is definitely hastened in Polygonum persicaria and P. scabrum by a 12-hour photoperiod. A photoperiod of 15 or more hours favors flowering of P. pensylvanicum. All these species will eventually produce flower buds under any reasonable photoperiod.

Once flower buds are initiated a higher favorable temperature promotes more rapid visual detection of the buds. One can tell by observation when floral buds have differentiated because of the narrowing and slight twisting of the leaves at the terminal.

An 18-hour photoperiod with the accompanying higher temperature and low light intensity was definitely unfavorable to the growth of P. scabrum. Plants grown under low light intensity tend to be taller and less well branched and have a reduced amount of roots, compared to those receiving adequate illumination.

References

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WEED CONTROL IN KENNEBEC POTATOES (R.I. 1963)¹R. S. Bell and J. B. Regan²

Testing of new herbicides to determine the tolerances of potatoes and weeds to these chemicals is needed for the development of more efficient means of weed control. Bell and Regan (1) reported that during 1962 an excellent crop of Kennebec potatoes was grown without any mechanical cultivation where adequate amounts of linuron or prometryne were used at emergence.

Preemergence herbicide trials

Procedures

The experimental area was planted to hay-type pasture for several years. It was plowed in early October, 1962 to initiate decomposition of the sod. While fairly level, there were variations in microtopography. The soil is a Bridg-hampton silt loam and was fertilized before harrowing in the spring with 200 lb/A of Cyanamid. A granular 10-10-10-2 L.C. fertilizer was banded at 1800 lb/A at planting.

The plots were eight rows wide and 48 feet long. Four replicates of each treatment were used, randomized within each of four blocks. The sprays were applied with a tractor-drawn low-pressure sprayer at the rate of 40 gallons water per acre. Dry materials were mixed with sand and spread by hand. The herbicides were applied May 8 or about 2 weeks before emergence of the potatoes.

Three tests were included in these trials. (a) miscellaneous herbicides with no cultivation, except hand-hoed checks until June 19 and 20 when all plots were cultivated and hilled. (b) a comparison of linuron, prometryne and H 7531 with and without cultivation. (c) effect of 4(2,4-DB) and 2,4-D on yields.

The mean rainfall, temperature and evaporation for the 1963 growing season are shown in Table 1. Rainfall in May was satisfactory with 3.71 inches falling between May 11 and 30. The June rainfall was about 50 percent of normal. Over one-half the July rainfall was on the last day of the month. Block 1 contained an area which did not supply enough moisture during the drought to keep the potatoes from wilting.

Table 1. Mean rainfall, temperature (FO) and evaporation (Kingston, R.I. 1963).

	Precipitation inches		Temperature		Evaporation inches
	Normal	1963	Normal	1963	
	mean		mean		
May	3.49	4.82	55.7	55.2	4.90
June	3.06	1.45	64.2	65.3	5.38
July	2.57	4.69	70.1	70.8	5.42
August	4.66	2.81	68.9	67.4	4.81

Results

Miscellaneous herbicide tests

The materials used and counts of dicot and grass seedlings on June 17, before cultivation are shown in Table 2. The yields of U.S. No. 1 Kennebec potatoes and the estimate of ladythumb (Polygonum persicaria L.) are in Table 3. The sources of the chemicals and their composition are presented in an appendix.

Four random counts of annual grass and dicot seedlings were made on each plot on June 17. The results are reported in Table 2. Dacthal at 10 lb/A gave excellent control of annual grasses but not of the dicots. Alipur O DN at 2 qt/A was much more effective on dicots than on annual grasses. Alipur OC (12 1/2 G) at 30 lb/A (commercial preparation) effectively reduced both types of weed but was injurious to the potatoes. GS 12344 at 4 lb/A was the most satisfactory in promoting high yields and an excellent control of both kinds of weeds.

Again in 1963, variation of microtopography of the Bridgehampton soil produced sufficiently variable results to make rather wide variations in yield non-significant. The range of non-significant yields were 463 to 315 cwt/A. The lower yields of potatoes from the last five treatments in Table 3 were probably due to poor weed control by paraquat at 1 lb/A and to definite injury to the potatoes by SD 7961 and the granular Alipur preparations.

SD 7961 injured the tubers so that many seed pieces did not product plants. Granular preparation of Alipur at 30 lb/A (commercial preparation) depressed the growth of potato plants. The granular O DN at 15 lb/A showed slight retardation. Interestingly, in mid-August when the vines in the other treatments had matured, the formerly injured plants had recovered and were growing vigorously. The SD 7961 plots contained crabgrass where the potato plants were missing.

The variation among ratings of the natural stand of ladythumb was such that statistically most of the differences were not significant. It seems of some importance, however, that the materials which damaged the early growth of potatoes, SD 7961 and some of the Alipur materials rated high in suppression of this weed. Hand hoeing and GS 12344 also seemed more helpful in suppression of ladythumb. Prevention or elimination of Polygonum seedlings early in season is the forerunner of good control of this weed.

Linuron, prometryne and H 7531, with and without cultivation

Procedures

The wettable powders of linuron, prometryne and H 7531 were applied on May 7, preemergent to the potatoes at rates of 2 and 3 lb/A active toxicant. Four replicates of each treatment were randomized in each of four blocks. Four plots without herbicides were retained as checks.

The two north rows of each block were cultivated on June 12 and 19. The two south rows were also cultivated on these dates and hilled on June 20. Four rows without cultivation remained in the central part of each block.

Table 2. Random weed counts, June 17, 1963.

Average number of dicots per 4 square feet			Average number of grasses per 4 square feet				
Material	Toxicant per acre	Dicots	Duncan Signif- icance	Material	Toxicant per acre	Grasses	Duncan Signif- icance
Paraquat	0.5 lb	28.3	*	Alipur O 10G	1.5 lb	42	*
Paraquat	1.0 lb	22.3	†*	Paraquat	1.0 lb	37	†*
Prometryne 150E	3.0 lb	19.5	††*	Alipur O DN	2.0 qt ^x	37	††*
Alipur O 10G	1.5 lb	17.0	††*	Paraquat	0.5 lb	36	††*
Dacthal	10.0 lb	15.0	†††*	GS 12344	2.0 lb	35	†††*
Alipur O DN	1.0 qt ^x	14.8	†††*	Alipur O DN	1.0 qt ^x	35	†††*
Alipur OC 12½G	15.0 lb ^x	11.0	††††*	Prometryne 150E	3.0 lb	28	††††*
GS 12344	2.0 lb	9.3	††††*	Alipur OC 12½G	15.0 lb ^x	24	††††*
Alipur O 10G	3.0 lb	8.8	††††*	Alipur O 10G	1.5 lb	11	††††*
Alipur O DN	2.0 qt ^x	8.5	††††*	SD 7961	4.0 lb	10	††††*
GS 12344	4.0 lb	4.3	††††*	Hand-hoed check	-	8	††††*
Hand-hoed check	-	3.5	††††*	GS 12344	4.0 lb	7	††††*
SD 7961	4.0 lb	0.5	††††*	Alipur OC 12½G	30.0 lb ^x	5	††††*
Alipur OC 12½G	30.0 lb ^x	0.5	††††*	Dacthal	10.0 lb	1	††††*

* = Amount of commercial material rather than toxicant.

Table 3. Yields of U.S. No. 1 Kennebec potatoes and ladythumb rating (URI, 1963).

Yield		Duncan		Yield		Duncan	
Material	Toxicant per acre	Cwt/A US #1 tubers	Signif- icance	Material	Toxicant per acre	Rating*	Signif- icance
Dacthal	10.0 lb	463	*	SD 7961	4.0 lb	9.5	*
Alipur O DN	2.0 qt ^x	441	†*	Alipur OC 12½G	15.0 lb ^x	9.1	†*
Hand-hoed check	-	441	††*	GS 12344	4.0 lb	9.0	††*
GS 12344	4.0 lb	433	†††*	Alipur O 10G	30.0 lb ^x	8.1	†††*
Paraquat	0.5 lb	430	††††*	Hand-hoed check	-	7.9	††††*
Alipur OC 12½G	15.0 lb ^x	424	††††*	GS 12344	2.0 lb	7.6	††††*
Prometryne 150E	3.0 lb	421	††††*	Alipur O DN	2.0 qt ^x	6.6	††††*
Alipur O DN	1.0 qt ^x	403	††††*	Dacthal	10.0 lb	6.4	††††*
GS 12344	2.0 lb	394	††††*	Alipur OC 12½G	30.0 lb ^x	6.2	††††*
Paraquat	1.0 lb	388	††††*	Paraquat	1.0 lb	5.9	††††*
Alipur O 10G	1.5 lb	362	††††*	Alipur O 10G	15.0 lb	5.1	††††*
SD 7961	4.0 lb	352	††††*	Prometryne 150E	3.0 lb	4.5	††††*
Alipur OC 12½G	30.0 lb ^x	315	††††*	Paraquat	0.5 lb	4.1	††††*
Alipur O 10G	3.0 lb	210	††††*	Alipur O DN	1.0 qt	4.0	††††*

* = 10, 100% control; 1, no control.

x = Amount of commercial material rather than toxicant.

The data from the first block were not used in the statistical analyses because potatoes showed drought symptoms plus damage by an invasion of leafhoppers from a nearby alfalfa field. This injury occurred over a weekend in early August. Insecticides and fungicides were applied several times during the growing season.

Results

The rows of potatoes which were cultivated appeared slightly taller and greener than the uncultivated ones. This was particularly noticeable on the droughty block 1. Hilling in addition to cultivation did not further enhance the appearance of the potato plants.

The yields of U.S. #1 Kennebec potatoes and weed ratings are shown in Table 4. They range insignificantly from 429 to 399 cwt/A. There were no significant differences in yield between cultivated and uncultivated plots where herbicides were used. Potatoes which were cultivated without herbicides were equal to those which received herbicides but no cultivation. When both cultivation and herbicides were omitted the weed population was high and the yield of tubers significantly less. The most complete weed suppression resulted from linuron at 3 lb/A. This is probably the practical upper limit for this compound. During 1962 reduced yields resulted from linuron at 4 lb/A. Weed control with 2 lb/A of linuron is adequate. On a silt loam soil recently in sod and in good physical condition cultivation does not seem necessary if an adequate herbicide is used. Cultivation, however, is still a satisfactory method of control. A combination of herbicides and cultivation may be more important where perennial weeds are concerned.

Table 4. Yields of Kennebec potatoes (cwt/A) and numbers of dicot and grass weeds per 4 square feet (URI, June 17, 1963) as affected by Linuron, Prometryne and H 7531.

Treatment	lb/A toxicant	Cwt/A	Dicot seedlings	Grass seedlings	Ladysthumb rating
Linuron	3	429	0.0	0.0	10
Prometryne	3	424	1.3	3.0	9
Prometryne	2	416	3.0	3.5	9
No herbicide + cultivation	-	414	*	*	9
H 7531	3	409	1.5	1.2	9
Linuron	2	405	0.5	6.7	9
H 7531	2	399	3.4	8.0	8
No herbicide-no cultivation	-	288**	26.0**	33.0**	1**

*Counts made before any cultivation so same as no herbicide check.

**Significant difference by Duncan's multiple range test.

Evaluation of 4(2,4-DB) and 2,4-D

Procedures

Just north of the miscellaneous herbicide test was an area of Kennebec potatoes which received normal cultivation and hilling, and which remained prac-

acid equivalent to see how they would influence the yield of tubers. The rates, dates and production in cwt/A are shown in Table 5. The yields ranged from 395 to 467 cwt/A and no statistically significant differences were obtained among the treatments.

Table 5. Effect of 4(2,4-DB) and 2,4-D on yields of Kennebec potatoes (R.I. 1963).

	AE lb/A	Cwt/A US #1	Cwt/A US #1
	4(2,4-DB)	2,4-D	
June 12	0.50	395	-
June 12	1.00	398	-
July 12	0.25	451	449
August 12	0.50	421	439
Check	0.00	467	467

4(2,4-DB) caused severe deformation of new growth in June and July. By August the vines were maturing and the change was not so noticeable. Where growing conditions were good, the signs of damage became much less noticeable within two weeks. In sections where drier soil retarded growth injury symptoms persisted for a month or more. Injury by 2,4-D was not quite as severe as that from 4(2,4-DB).

It appears that yields of Kennebec potatoes are not adversely affected by moderate amounts of these two materials. Some of the tubers were placed in storage for quality tests during the winter months.

Summary

Several new herbicides showed promise of controlling annual weeds without decreasing yields of potatoes. These were linuron 80W, prometryne 80W, H 7531 and GS 12344. Linuron seemed the most effective but may have to be used more carefully than the others. Dacthal 75W gave excellent control of annual grasses but was not particularly effective on dicots. Some of the materials were damaging to potatoes when used in sufficient quantities to obtain good control of annual weeds. Some of the Alipur preparations and SD 7961 were in this group. High yields of Kennebec potatoes were obtained without cultivation where an adequate herbicide was used. Likewise cultivation without herbicides was equally effective on this Bridgehampton silt loam soil. In general, cultivation improved the appearance of the potato vines during the dry period in July. Less than one pound acid equivalent did not lower potato yields of 4(2,4-DB) and 2,4-D.

Reference

Bell, R. S. and J. B. Regan. 1963. Weed control in Kennebec potatoes (R.I. 1962). NEWCC 17: 167-172.

Appendix

- Alipur O 10G 10% N-cyclooctyl-N'-dimethylurea (Naugatuck)
- Alipur OC 12.5G+7.5% N-cyclooctyl-N'-dimethylurea+isopropyl N(3-chlorophenyl) carbamate
- Alipur O DN 23.65 N-cyclooctyl-N'-dimethylurea+35.5% DNBP
- Dacthal 75W dimethyl ester tetrachloroterephthalic acid (Diamond Alkali)
- Hercules 7531 (80W) 1-5-(3a,4,5,6,7,7a-hexahydro-4,7-methanoindandyl)-3,3-dimethylurea
- Linuron (80W) 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (DuPont)
- Paraquat (2 lb/gal) 1:1-dimethyl-4,4'-dipyridylium dichloride (Cal. Chem.)
- Prometryne 150E (1 1/2 lb/gal) 2,4-bis(isopropylamino)-6-methylmercapto-s-triazine
- Prometryne 80W 2,4-bis(isopropylamino)-6-methylmercapto-s-triazine (Gaigy)
- SD 7961 2,6-dichlorothiobenzamide (Shell)

Potato Herbicides: A Summary of Their Performance Under Three Years^{1/}
of Field Testing

G. H. Bayer^{2/} and R. D. Sweet^{3/}

The wide range in climate, soil type, weed species and cultural practices among the potato growing areas of the northeastern United States presents many problems in developing a satisfactory weed control program for this crop. It is unlikely that any one chemical as part of a weed control program will be satisfactory over the entire region.

Several herbicides, i.e., dinitro, dalapon, EPTC and CDAA have been available commercially for some years and to a limited extent have been accepted by commercial growers. Varying results with the above materials have pointed out the need for continued research in the development of a more effective potato herbicide. In the last three years more than a hundred new compounds have been field tested and from these several show promise. They have been studied in relation to crop safety and effectiveness against annual broadleaved and grassy weeds. Most have also been tested for toxicity to nutgrass. The purpose of this paper is to summarize the performance of CDAA+CDEC, Bayer 40557, Hercules-7531, diphenamid and linuron.

Methods

Certain of the procedures were fairly uniform throughout all tests, others were specific for a particular test or compound. The general methods will be described here and the special methods will be described at the appropriate time. The majority of tests were conducted on fairly well drained gravelly loam soils and a few were on muck. Those tests on farmers' fields were given the normal cultural practices of that particular operator. This usually meant 3-5 cultivations plus a hilling at lay-by. Tests were usually harvested in September well before frost and the vines of necessity had to be treated with a vine killer to facilitate harvest. The potato variety in all tests but one was Katahdin.

Liquid materials were applied by means of a small plot CO₂ sprayer at about 50 gallons to the acre and 40 pounds pressure. Granular compounds were applied by means of hand-shaker device. Plots normally were single rows each 15 to 25 feet in length. Replication varied from 2 to 4.

Weeds in most plots were predominately annual broadleaves such as lambs-quarters, redroot pigweed, and ragweed. In a few cases annual grasses such as foxtail and barnyard grass were important. Effectiveness on weeds was measured by visual ratings with complete control given the highest rating, "9"; a few weeds but still considered commercially acceptable to the farmer, "7"; and a rating of "1" was assigned when there was complete heavy ground cover.

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Foliage response of potatoes was noted and any chemical showing marked foliage symptoms was arbitrarily judged not acceptable. At harvest time total yield per plot was taken by weight. Any visual tuber abnormalities were noted and for the more promising compounds, 10 pound samples taken and placed in common storage for observations on storage life, specific gravity and, in a few instances, chipping quality. Also, residue analyses were determined for certain compounds.

Results and Discussion

Summary data from the more pertinent experiments will be presented to illustrate the effect of environmental and cultural factors on several selected herbicides.

Soil Type

Linuron, the combination of CDAA plus CDEC and H-7531 were studied on both mineral and muck soil. This work was done in 1962 and has been reported previously by Bayer and Sweet (2). Weed species present in the mineral soil included ragweed, lambsquarters, and redroot. Weed species at the muck location were lambsquarters and redroot. It was found that both linuron and H-7531 were less effective on the muck soil (Table 1). By contrast the combination of CDAA plus CDEC performed consistently better on the muck soil. Earlier work by Gialone and Sweet (4) and commercial use of these materials has shown the combination of these materials appears to enhance the activity and broaden the spectrum of both broadleaf and grass weeds beyond what either CDAA or CDEC would do alone.

Table 1. The effect of soil type on the performance of herbicides applied at planting.

Chemical	lbs/A	Soil Type	Weed control ^{1/} Rating	Potatoes bu/A
linuron	2	muck	8.0	520
"	2	mineral	9.0	460
H-7531	3	muck	7.3	530
"	3	mineral	9.0	492
CDAA+CDEC	4+4	muck	8.3	562
"	"	mineral	8.0	475
Cultivated Check		muck	5.0	66
"	"	mineral	3.8	96

^{1/} 9 = complete kill. 7 = commercially acceptable control.

Timing

Trevett et al. (8) and Bell and Regan (3) have reported excellent weed control with several pre-emergence chemicals including linuron. Other workers including Hawkins (5) and Sawyer and Dallyn (7) report lay-by applications of granular materials gave very good results.

Compounds were evaluated both before and after weed emergence. In these particular experiments the predominant species were ragweed and lambsquarters. Unfortunately, many chemicals which had good post-emergence activity on weeds also gave foliage injury and/or potato yield decreases. For example, linuron, Bayer 40557 and H-7531 when applied as liquid sprays on potato foliage caused anywhere from slight to severe chlorosis and significant yield reductions (table 2). However, when used at planting at rates adequate to give full-season weed control there was no chlorosis or reduction in yield.

Table 2. The effect of time of application on the performance of herbicides on mineral soil.

Chemical	Ave. lbs/A	Timing	Weed Control Rating ^{I/}	Potatoes bu/A
<u>Test A</u>				
linuron	2,4	at planting	9.0	454
"	"	pre-emergence	9.0	420
"	"	early post-emergence	9.0	374
"	"	lay-by	9.0	246
H-7531	3,6,9	at planting	9.0	403
"	"	pre-emergence	9.0	362
"	"	early post-emergence	9.0	356
"	"	lay-by	9.0	358
CDAAC+CEC	4+4	pre-emergence	8.0	475
"	"	early post-emergence	6.5	450
Cultivated check			3.8	96
----- <u>Test B</u>				
Bayer 40557	4	pre-emergence	8.8	554
"	"	early post-emergence	9.0	390
diphenamid	1,2,4	pre-emergence	7.8	578
		early post-emergence	4.0	495
Cultivated check			3.0	415

I/ 9 = complete kill; 7 = commercially acceptable; 1 = complete heavy ground cover.

On the other hand, diphenamid and the combination of CDEC and CDAAC have little post-emergence activity on either crop or weeds. Thus, in spite of the fact that the post-emergence applications were made on freshly cultivated plots, significantly poorer weed control and decreased yields resulted. The yield decrease was probably caused by weed competition rather than chemical damage.

Cultural practices

Since cultural practises for potatoes vary between growers and between areas, it was decided to study cultivation and irrigation at several levels. Using a no-crop culture but studying the effect of cultivation and irrigation on linuron and H-7531, Bayer, et al (1) reported that weed control was decreased in the case

of both compounds by cultivation immediately following application (table 3). However, it was enhanced when cultivation was delayed for three weeks. Irrigation, on the other hand, had no significant effect on weed control.

Table 3. The influence of cultivation on the activity of several herbicides, mineral soil.

Chemical	Ave. lbs/A	Cultivation Practise <u>Test A</u>	Weed control Rating ¹		Potatoes bu/A
			Broadleaf	Grass	
linuron	0.5, 2.0	none	8.0	-	-
"		once, immediate	7.0	-	-
"		once, after 3 weeks	8.6	-	-
H-7531	3.0, 6.0, 9.0	none	8.4	-	-
"		once, immediate	7.7	-	-
"		once, after 3 weeks	8.8	-	-
<u>Planted early May</u>					
<u>Test B</u>					
H-7531	1.6, 2.4, 3.2	once	7.5	7.5	615
"		four times	8.4	8.8	680
Check		once	1.0	1.0	380
"		four times	3.5	2.0	625
<u>Planted early June</u>					
H-7531	1.6, 2.4, 3.2	once	8.8	9.0	520
"		four times	8.9	9.0	585
Check		once	2.1	1.2	390
"		four times	7.3	5.0	524

¹/9 = complete kill; 7 = commercially acceptable; 1 = complete heavy ground cover.

That same year, experiments conducted in commercial potato fields received the growers regular cultivation program consisting of up to four cultivations plus a hilling. Under these conditions linuron, H-7531 and CDAA plus CDEC combination always gave better weed control than cultivated checks.

In 1963, H-7531 was investigated in considerable detail as to the effect of time of planting and cultivation frequency. The pertinent data on these two factors are shown in the lower part of table 3. Both planting dates indicate the advantage of cultivation with H-7531 as measured by grass and broadleaf weed control and potato yield. Weed species in these latter tests involved natural stands of ragweed, lambsquarters and smartweed as well as a broadcast seeding of barnyardgrass made at planting.

Rates

The choice of a rate or range of rates is influenced by many factors, but a few factors such as activity of the compound on weeds, crop safety, influence

of soil and environment, and the timing of the application are particularly important. Work with potato herbicides was conducted for several years over a wide range of conditions during which time the range of rates was frequently revised. The data in table 4 illustrate weed and potato responses to pre-emergence applications of several herbicides on mineral soils in 1963 at rates thought to be best for each compound. It is apparent that weed control performance of all materials except B-40557 was greatly influenced by the range of rates studied. Furthermore, at the highest rates only B-40557 reduced potato yield suggesting that in future tests, lower rates should be investigated.

Table 4. The effect of rates on performance of herbicides applied pre-emergence on mineral soil.

Chemical	lbs/A	Weed control Rating ¹	Potatoes bu/A
linuron	.5	5.8	568
"	1.0	8.0	558
"	1.5	9.0	586
diphenamid	1.0	7.0	554
"	2.0	7.5	589
"	4.0	8.8	596
Bayer 40557	2	8.3	536
"	4	8.8	554
"	8	9.0	349
H-7531	1.6	6.5	600
"	2.4	7.2	626
"	3.2	8.0	620

¹/9 = complete kill; 7 = commercially acceptable; 1 = complete heavy ground cover.

Weed Response

The weed control ratings presented in previous sections of this paper represent primarily results with annual broadleaved species because they predominated in practically all of the potato fields where tests were conducted. In the 1963 tests, however, seedings were made with barnyard grass in order to assure a heavier population of annual grass.

Since the compounds being studied in potatoes were also undergoing intensive testing with many other crops and at several other locations, data were obtained on their activity against a wide range of weed species. From all tests, broadleaf species included: galinsoga, groundsel, lambsquarters, mustard, purslane, ragweed, redroot pigweed, and smartweed; annual grasses included: crabgrass, barnyardgrass, stinkgrass (*Eragrostis* sp.) and yellow foxtail; perennials were: quackgrass, nutsedge, and groundcherry.

Generally speaking, diphenamid, CDAA and CDEC were not active except pre-emergence. In contrast B-40557, H-7531, and linuron were active on weeds both pre- and early post-emergence. Linuron was slightly less effective on grasses than on broadleaves, particularly at lower rates. Diphenamid, however, was more

effective on grasses than broadleaves. B-40557, H-7531, and CDAA+CDEC were very effective against both broadleaves and grasses. None of the materials studied showed acceptable activity against nutgrass, groundcherry or quackgrass at rates and timings safe on potatoes.

Summary

Approximately 100 newer chemicals were evaluated to a limited extent under field conditions as to their potential for selective herbicides in potatoes. Five of the more promising materials were chosen for detailed evaluation. The effects of time and rate of application, cultivation, irrigation, soil type and weed species were studied for three years.

Time of application in relation to both potato and weed development was soon shown to be one of the most definitive factors under study. Since post-emergence applications were often more damaging to the crop as well as less effective on weeds than pre-emergence treatments, more research effort was devoted to the latter.

Most of the tests were conducted in fields where annual broadleaves rather than annual grasses predominated. This could well be an important factor in making applications of the data obtained.

The effect of soil type was investigated only in a gross way, mineral vs muck. No attempt was made to determine specifically which soil constituents were responsible for the fact that somewhat more chemical was required on muck than on mineral soils to accomplish comparable results. CDAA plus CDEC, however, was a notable exception because this treatment was relatively more effective on muck than on mineral soils.

Cultivation was studied as a normal cultural practise rather than as a technique for herbicide incorporation. However, it actually served to incorporate chemicals somewhat, particularly when done soon after treating. Subsequent cultivation enhanced rather than decreased chemical performance. Thus it appears that normal cultural practises with potatoes do not need to be modified in order to insure that these newer herbicides will be effective.

Conclusions

1. None of the materials under study as potato herbicides were seriously influenced by the natural variations in soil moisture, rainfall and temperature encountered during the thrre-year-perido of these tests.

2. Cultivation 2-3 weeks after pre-emergence application increased weed control, whereas cultivation immediately after application often decreased weed control. Pre-emergence applications of the more promising chemicals generally resulted in season-long control of annual weeds with or without repeated cultivation.

3. The combination of CDAA plus CDEC at planting is the most promising herbicide for potatoes on muck soils.

4. Post-emergence applications were generally more toxic to the crop and less effective on weeds than were pre-emergence applications, thus emphasizing that an herbicide active on weeds post-emergence but safe on potatoes regardless of their stage of development is still needed.

5. Perennials were not selectively controlled in potato fields.

6. It is hoped these results will assist other research workers in determining which chemicals are most likely to assist them in solving weed problems of potatoes in their areas.

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CONTROL OF LATE GERMINATING WEEDS IN POTATOES¹R. L. Sawyer and S. L. Dallyn²

The problem of late germinating weeds in potatoes on Long Island has increased in recent years. Part of this increase can be directly attributed to a change from Green Mountain variety which shades the ground to Katahdin variety with its open foliage relatively early in the maturing season. Some growers choose their present potato variety according to the weed problem in a specific field. Cultural techniques greatly influence the weed problem; however, in many cases some chemical control is essential with most of the present day varieties. This report is a continuation of work included in previous proceedings.

MATERIAL AND METHODSPlanting Date: April 12, 1963

Harvest Date: September 12, 1963

Variety: KatahdinFertilization: 175 lbs/A N; 350 lbs/A P₂O₅; 175 lbs/A K₂OCultivation: 5 cultivations and weedingIrrigation: 5 applications of 1 inchPlot Size: Single row, 30 feet long - check on either sideStatistical Design: Randomized blockOther:

Soil incorporated materials were applied before last cultivation on June 19. Lay-by materials were applied on June 20 after last cultivation and contact killers were applied June 27. Granular materials were applied with a "Gunkle" applicator.

Chemicals were applied on two farms. Materials were tested at the Research Station to determine the phytotoxicity of potatoes to the chemicals. They were tested on a commercial farm with a serious weed problem to determine herbicidal activity. The weed population consisted of both broadleaved weeds and annual grasses with barnyard grass the most prominent.

Results and Discussion:

Eptam applied before last cultivation continues to give as good performance as any material tested. R-1607 gave comparable results to Eptam. A dosage of 4 lbs. per acre was necessary to give commercial weed control with both.

Diphenamid at 8 lbs. per acre as a granular was very effective. However, as a wettable powder the same dosage gave unsatisfactory control, similar to the 1962 results.

Alipur O and Alipur OC gave good weed control but tended to decrease potato yields. This was also true for both Lorox and Stam. Linuron as low as 1 lb. per acre gave good weed control. Neither Falone or Radox gave satisfactory weed control at 4 lbs. per acre.

In potato weed control, increasing the dosage of a chemical does not always result in better weed control. The reverse may be the case with certain chemicals which give damage to potato foliage. As the foliage damage is increased, the weed problem is increased and this may be greater than the increase in herbicidal action due to heavier dosages of a given chemical. This was true with both SD 7961 and Stam.

Samples from all plots are being followed through storage and processing for any possible effects on storage or cooking quality. The field results are given in Table 1.

Table 1. Field results with chemicals applied to potatoes to control post-emergence weed problems.

<u>Material</u>	<u>% Active</u>	<u>Lbs.Active per Acre</u>	<u>Weed Control % of Check</u>	<u>U.S. No. 1 Cwt/A</u>	<u>2-3$\frac{1}{2}$" Cwt/A</u>
Alipur O	10G	1.5	90	283	212
		3.0	90	311	216
Alipur OC	12 $\frac{1}{2}$ G	1.5	85	309	210
		3.0	90	257	190
TOK	10G	6.0	75	282	185
		8.0	75	295	190
SWEP	5G	4.0	70	297	210
		6.0	90	304	226
Diphenamid	5G	8.0	90	322	212
		12.0	95	308	194
Linuron	10G	1.0	85	351	209
		2.0	90	369	212
		3.0	80	295	209
Randox	20G	4.0	50	313	187
Falone	10G	4.0	50	284	226
Prometryne	4G	2.0	80	279	193
R-1607	10G	3.0	50	297	202
		4.0	90	331	224
		5.0	85	342	241
Eptam	10G	3.0	70	329	200
		4.0	85	324	205
		5.0	90	290	200
SD 7961	5G	1.0	70	243	159
		2.0	20	181	134
		6.0	30	242	166
BP9	97 w.p.	4.0	20	236	171
Diphenamid	50 w.p.	8.0	50	324	215
		1.0	85	257	190
Lorox	50 w.p.	2.0	90	194	142
		1.0	50	314	195
Stam	35 w.p.	1.0	40	284	190
		2.0	0	323	202
Check			0	323	202
	L.S.D. 5% level			38	25

POTATO VINE KILLING¹R. L. Sawyer and S. L. Dallyn²

Materials used for potato vine killing serve a dual purpose of killing both potato vines and weeds which have grown during the ground storage period. This is a continuation of work at finding materials strong enough to kill weeds and potato vines over a 10-day period, yet selective enough to kill potato vines slowly over this period.

MATERIAL AND METHODS

Planting Date: April 16, 1963 Harvest Date: September 30, 1963
Variety: Katahdin and Kennebec
Fertilization: Lbs. per acre: Nitrogen-175; P₂O₅-350; and K₂O-175
Cultivation: 5 cultivations and weeding
Irrigation: 4 applications of 1 inch
Plot Size: 2 rows 30 feet long
Statistical Design: Randomized block
Other:

Vine kill ratings were made 2, 4 and 8 days after application of chemicals according to the following rating plan:

- 1) No kill
- 3) 50% kill of leaves
- 5) 100% kill of leaves
- 7) 100% kill of leaves - 50% kill of stems
- 9) 100% kill of leaves - 100% kill of stems

Results and Discussion:

In almost every case every material at each dosage gave a greater degree of kill with Katahdin than with Kennebec variety. Kennebec is a later maturing variety than Katahdin. Vines which are nearing maturity are much easier to kill than vigorously growing vines.

This program on new potato vine killers has been in operation for seven years. U.C. 20299 and U.C.19909 come as close as any material tested in that period to producing the ideal type of kill. Initial kill is slow, allowing some increase in tuber growth as vines are dying. The kill at the end of eight days is as good as that obtained with other killers.

Des-I-Cate, Diquat and Paraquat all give a very good kill at low dosages. The speed of kill is too fast, however, for the best physiological development of skin and tuber in maturation.

BB/248/62-A and BB/248/62-B, chlorate materials, appear to give the slow type of initial kill at dosages up to 16 lbs. per acre. Both of these were compared to sodium arsenite in a test initiated one week later than the

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work covered in Table 1. Four days after application, BB/248/62-A had a kill rating of 3.5 at 16 lbs. per acre when sodium arsenite had a kill rating of 7.5 at 4 lbs. per acre.

RO 4-6340, a new material which was run through a basic screening program late in the season, appeared to have very good potato vine killing possibilities.

Most of the field results for work conducted in 1963 are given in Table 1. Samples are being followed through storage and processing for effects on tuber quality.

Table 1. Results with chemical vine killers on Katahdin and Kennebec potato varieties.

<u>Material</u>	<u>Dosage</u>	<u>U.S. No. 1</u>		<u>2-3$\frac{1}{2}$" size</u>		<u>Vine Kill Rating</u>	
		<u>Katahdin</u>	<u>Kennebec</u>	<u>Katahdin</u>	<u>Kennebec</u>	<u>Katahdin</u>	<u>Kennebec</u>
U.C. 20299	1.5	317	314	219	198	2-4-6	1-2-2
"	3.0	339	300	210	183	2-6-7	3-5-7
"	5.0	342	342	152	186	2-5-7	3-6-7
U.C. 19909	1.5	326	310	183	196	4-7-8	1-2-4
"	3.0	351	334	183	223	2-3-8	1-2-5
"	5.0	376	367	189	189	3-6-8	2-6-8
Des-I-Cate	.5	372	346	202	230	2-3-8	4-6-7
"	1.0	343	307	175	215	5-8-8	6-7-7
"	1.5	297	292	175	184	7-8-8	7-7-8
Diquat	.25	302	---	178	---	2-6-8	---
"	.50	360	314	225	183	4-7-8	4-6-7
"	.75	358	291	225	198	5-7-9	4-6-8
Paraquat	.25	315	---	196	---	4-6-8	---
"	.50	326	320	225	191	4-7-9	3-5-7
Sodium Arsenite	2.0	351	321	201	218	2-4-6	3-4-7
"	4.0	357	324	183	207	5-7-9	3-6-7
"	6.0	342	337	198	202	4-7-8	4-6-7
"	8.0	335	325	221	221	6-8-9	7-8-8
Check		317	352	209	234	1-1-1	1-1-1
L.S.D. 5%		54	73	51	53		

ANNUAL WEED CONTROL IN POTATOES FOLLOWING PLANTING AND PREEMERGENCE

TREATMENTS

M.F. Trevett, H.J. Murphy, and William Gardner^{1/}

INTRODUCTION

This paper is a report on annual weed control in white potatoes obtained with the herbicides listed in Table 1.

PROCEDURE

Katahdin potatoes were planted in loam and sandy loam soils. Seed pieces were spaced 12 inches in rows 42 inches apart.

Treatments were replicated five to eight times in randomized blocks of single row plots paired with untreated plots. Herbicides were applied with one pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. Potatoes were hilled two or three times. The final hill was approximately 24 inches wide at the base, 10 inches high, and 6 inches wide at the top.

Granular herbicides were broadcast and disked in to a depth of 4-6" within ten minutes of application.

The principal weeds were: Wild rutabaga (Brassica rapa L.); Red root pigweed (Amaranthus retroflexus L.); Lambsquarters pigweed (Chenopodium album L.); Barnyard grass (Echinochloa crusgalli (L.) Beauv.).

Rainfall data are found in Table 2.

RESULTSPlanting and Preemergence Application

Four and one-half pounds of DNBP plus 7.4 pounds Dalapon per acre applied preemergence produced higher yields in Block A,

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Table 3, then all other treatments except preemergence application of 6 pounds Diphenamid plus 4.5 pounds DNBP, 6 pounds Swep 80W plus 7.4 pounds Dalapon, and planting application of 4 pounds Swep EC, or 3 pounds Linuron 50W.

The four latter treatments: 4 pounds Swep EC, 6 pounds Diphenamid plus 4.5 pounds DNBP, 3 pounds Linuron 50W, and 6 pounds Swep 80W plus 7.4 pounds Dalapon did not differ significantly in yield from planting applications of 6 pounds Swep 80W, 6 pounds Swep EC, 1 or 2 pounds Linuron 50W, 2 or 3 pounds Prometryne EC, or 6 pounds Solan EC.

Annual grasses did not affect yield in Block A. All of the herbicides used in this block except planting applications of 3 and 6 pounds H7531 80W, and 6 pounds Diphenamid 50W were giving satisfactory control of broadleaf weeds five weeks after planting. On September 30, approximately seventeen weeks after planting, 6 pounds Diphenamid 50W plus 4.5 pounds DNBP applied preemergence, and 3 pounds Linuron 50W applied at planting, gave significantly higher broadleaf weed control than all other treatments except preemergence application of 6 pounds Swep 80W plus 7.4 pounds Dalapon, or 4.5 pounds DNBP plus 7.4 pounds Dalapon and planting application of 2 pounds Linuron 50W, 6 pounds Swep EC, or 3 pounds Prometryne EC. The extended period of satisfactory weed control may have resulted from the rainfall pattern: insufficient rain to stimulate a second or third flush of weed seed germination until after potato plants had made sufficient top growth to shade out newly germinated seedlings.

Preemergence Application

In Block B, a preemergence test, all treatments except 6 pounds Diphenamid 50W were giving excellent broadleaf weed control seventeen weeks after planting, Table 4. In three comparisons, Diphenamid showed additive action:

<u>Treatment</u>	<u>Means converted to angles</u>	<u>Means: %</u>
3# Stam plus 6# Diphenamid	76.04	94.2
6# Solan plus 6# Diphenamid	74.94	93.3
1# Paraquat plus 6# Diphenamid	72.65	91.1
3# Stam	66.68	84.3
1# Paraquat	64.14	81.0
6# Solan	63.54	80.1
6# Diphenamid	19.47	11.1
L.S.D. 5%	5.11	

Linuron plus 1 percent Surfactant WK did not control annual broadleaf weeds better than Linuron alone. In another test, concentrations of .25 and .50 percent Surfactant WK in a Linuron spray did not significantly increase broadleaf weed control. Similarly, concentrations of .50 and .75 percent Surfactant WK in Diuron sprays did not significantly increase broadleaf weed control. In these 1963 tests, surfactants did not increase the efficiency of Linuron and Diuron in early preemergence applications.

In another preemergence test, 1, 2, or 3 pounds per acre of Stam did not differ significantly in effect on either broadleaf weed control or yield, Table 5. One hundred gallons of oil applied preemergence gave excellent broadleaf control for four weeks, but did not hold, Table 5.

Granular Herbicides

Six pounds Diphenamid, and 4 or 6 pounds of R 4572 applied in granular formulation did not adequately control Wild rutabaga. Using Duncan's Multiple Range Test at the 5 percent level of significance, R 1607 and EPTC did not differ significantly either in effect on yield or control of Wild rutabaga.

Low yields in hand hoed plots in Blocks A, B, and C are the result of root pruning.

CONCLUSIONS

The standard treatment of 4.5 pounds DNBP plus 7.4 pounds Dalapon per acre applied preemergence, continued to give excellent broadleaf weed control. Candidate materials or mixtures that are promising and which have not differed significantly in effect on yield from the standard include: preemergence applications of 6 pounds Diphenamid plus 4.5 pounds DNBP, 6 pounds Swep 80W plus 7.4 pounds Dalapon, 1, 2, or 3 pounds of Stam, 1 pound of Linuron, 1 pound Paraquat, 6 pounds Solan, 6 pounds of Solan plus 6 pounds of Diphenamid, 4 pounds 2,4-DEP plus 3 pounds DNBP, and planting applications of 4 pounds of Swep, and 3 pounds of Linuron. In 1963, these materials and mixtures gave excellent broadleaf control throughout the growing season. Annual grasses were not present in sufficient quantity to have a significant effect on yield.

Diphenamid added to preemergence applications of Stam, Paraquat, or Solan increased broadleaf weed control significantly compared to applications of Stam, Paraquat, or Solan alone.

A surfactant did not increase the effectiveness of either Linuron or Diuron applied preemergence.

Table 1. Herbicides Used in Tests in 1963.

Designation	Active Ingredient
ALIPUR	OMU plus Butynyl-n-(3 chlorophenyl) carbamate
DALAPON	2,2-dichloropropionic acid
DIPHENAMID	N,n-dimethyl-diphenyl acetamide
DNBP	4,6-dinitro-o-secondary butylphenol
EPTC	Ethyl-di-n-propylthiolcarbamate
H -7531	1-(5-(3a, 4,5,6,7,7a-hexahydro-4,7-methanoindanyl) 3,3-dimethylurea
LINURON	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
OIL	"100 percent petroleum distillate" (American Mineral Spirits Company)
PARAQUAT	1,1'-dimethyl-4,4'-dipyridylum cation
PROMETRYNE	6-methylmercapto-2,4-bis (isopropylamino-s-triazine)
R 1607	N-propyl-di-n-propylthiolcarbamate
R 4572	Ethyl-1-hexamethyleneiminecarbothiolate
SOLAN	N-(3-chloro-4-methylphenyl)-2-methyl-pentanamide
STAM	3,4-dichloropropionanilide
SWEP	Methyl-3,4-dichlorocarbamilate (EC-emulsifiable; 80W-wettable powder)
2,4-DEP	Tris (2,4-dichlorophenoxyethyl) phosphite
SURFACTANT WK A DuPont product	

Table 2. Rainfall: May, June, July, August, 1963, Monmouth, Maine.

Date	Inches	Date	Inches	Date	Inches
May 18	.82	July 1	.47	August 5	.35
21	.44	7	.48	7	.32
22	.03	8	.40	9	.04
23	.02	14	.05	11	.03
29	.17	15	.01	13	1.01
31	.02	18	.16	14	.85
June 6	.28	20	.03	15	.04
8	.04	21	.02	17	.28
12	.08	29	.06	19	.11
18	.22	30	.04	20	.24
20	.34	August 1	.19	22	.18
21	.10	3	.33	23	.03
27	.05	4	.50	24	.02
				29	.02

Table 3. Pounds White Pota toes Per 25 Feet of Row, Number of Annual Grasses Per 3 Square Feet and Percent Annual Broadleaf Weed Control, Block A.

Acre rate of active ingredient (lbs.)		Lbs. per 25' row	Number of annual grasses per 3 square feet		Percent Annual Broadleaf Weed Control			
			5 August '63		9 July '63			
			Means converted	No. per 3 sq. ft.	Angles	%	30 Sept. '63	Angles
4.5# DNBP + 7.4# Dalapon,	Pre ^{1/}	47.9	.92	(.35) ^{2/}	84.44	99.64 ^{4/}	53.93	65
4# Sweb, 2EC,	PL	43.4	1.09	(.69)	72.71	91.1	38.09	38
6# Diphenamid 50W + 4.5# DNBP,	Pre	41.5	.78	(.11)	80.43	97.2	62.49	78
3# Linuron 50W	PL	41.0	1.10	(.71)	80.01	97.0	62.27	78
6# Sweb 80W + 7.4# Dalapon,	Pre	40.6	.78	(.11)	77.83	95.5	55.45	67
6# Sweb 80W	PL	39.1	1.61	(2.09)	73.61	92.0	43.97	48
6# Sweb 2EC,	PL	38.4	1.41	(1.49)	83.26	98.6	50.33	59
2# Linuron 50W,	PL	38.2	1.23	(1.01)	80.75	97.4	52.40	62
1# Linuron 50W,	PL	36.9	1.33	(1.27)	65.96	83.4	35.61	33
2# Prometryne EC,	PL	36.4	1.26	(1.09)	73.53	91.9	42.44	45
6# Solan EC	Pre	36.4	1.08	(.67)	72.16	90.6	39.78	40
3# Prometryne EC,	PL	36.1	1.44	(1.57)	67.60	85.5	47.01	53
Hand hoed		35.2	1.15	(.82)	38.67	39.0	--	--
4# Sweb 80W,	PL	33.6	1.57	(1.96)	68.60	86.7	37.66	37
6# 7531, 80W	PL	27.6	1.40	(1.46)	50.49	59.5	27.61	21
3# 7531, 80W	PL	25.3	1.60	(2.06)	40.97	43.0	20.43	12
6# Diphenamid 50W	PL	24.1	1.08	(.67)	40.20	41.6	20.35	12
L.S.D. 5%		7.0	.42	(Not computed)	13.5	Not computed	12.9	Not computed

- 1/ Pre = applied preemergence, 12 June '63. PL = applied 4 June '63. Planted 4 June '63. On 12 June, weeds were in cotyledonary stage. Variety: Katahdin.
- 2/ Means included within same bracket are not significantly different at the 5% level (Duncan's Multiple Range Test).
- 3/ Figures not in parentheses are the means of the data transformed using $\sqrt{X + .5}$. Figures in parentheses are the reconverted means.
- 4/ Forty broadleaf weeds per square foot in check plots.

Table 4. Pounds White Potatoes Per 25 Feet of Row, and Percent Annual Broadleaf Weed Control, Block B.

Acre rate of active ingredient: lbs. ^{1/}	Yield lbs. per 25' row	Annual Broadleaf Weed Control	
		30 Sept. '63	Means converted to angles
		Means	Means:
			%
1# Linuron	43.3	75.24	93.5 ^{3/}
3# DNBP + 7.4# Dalapon	41.2	67.89	85.8
4.5# DNBP + 7.4# Dalapon	40.5	71.23	89.6
1# Linuron + Surfactant WK	40.3	73.33	91.8
6# Solan	39.2	63.54	80.1
6# Solan + 6# Diphenamid	39.1	74.94	93.3
3# Stam	38.5	66.68	84.3
1# Paraquat	37.9	64.14	81.0
3# DNBP + 6# Diphenamid	37.6	67.23	85.0
0.5# Paraquat	37.0	60.06	75.1
4# 2,4-DEP + 3# DNBP	36.9	66.96	84.7
3# Stam + 6# Diphenamid	35.9	76.04	94.2
1# Paraquat + 6# Diphenamid	35.9	72.65	91.1
2# Alipur + 3# DNBP	35.5	73.88	92.3
Hand hoed	33.0	--	--
6# Diphenamid	18.3	19.47	11.1
L.S.D. 5%	5.7	5.11	(Not computed)

^{1/} All treatments applied preemergence, 10 June '63. Planted 22 May, '63. On 10 June, Barnyard grass had two true leaves; broadleaf weeds were 2" tall. Variety: Katahdin.

^{2/} Means included within same brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

^{3/} 43.6 broadleaf weeds per square foot.

Table 5. Yield of White Potatoes and Annual Weed Control Following Preemergence Application of Stam, Oil, and DNBP Plus Dalapon, Block C.

Acre rate of active ingredient (lbs.) ^{1/}	Yield lbs. per 25' of row	Annual Grass Control		Broadleaf Weed Control 30 Sept. '63	
		Means converted	No. per 6 sq. ft.	Means converted to angles	Means: %
2# Stam	37.5	.83	(.19) ^{3/}	64.93	82.00
1# Stam	36.7	1.25	(1.06)	64.65	81.60
3# Stam	35.3	.85	(.22)	62.39	78.50
4.5# DNBP + 7.5# Dalapon	34.6	1.08	(.67)	59.47	74.20
Hand hoed	22.7	.77	(0.9)	--	--
100 gallons oil	20.1	.93	(.36)	42.01	44.80
L.S.D. 5%	5.9	.53	(Not computed)	10.42	Not computed

^{1/} All treatments applied 10 June '63. Planted 22 May, '63. Variety: Katahdin.

^{2/} Duncan's Multiple Range Test: Means in same brackets not significantly different at the 5% level.

^{3/} Means not in parentheses are the means of data transformed using the transformation $\sqrt{X + .5}$. Means in parentheses are number of grass plants per 6 square feet.

^{4/} 35.7 broadleaf weeds per square foot.

Table 6. Yields of White Potatoes Per 25 Feet of Row Following Application of Granular Herbicides.

Acre rate of active ingredient: lbs. ^{1/}	Pounds per 25' of row	Annual Broadleaf Weed Control	
		Means converted to angles	Means: ^{2/} %
4# R 1607	46.0	73.40	91.8
Hand hoed	45.8	74.56	93.9
4# EPTC	42.7	66.01	83.5
6# R 1607	41.3	71.43	89.8
6# EPTC	39.4	74.56	93.9
6# Diphenamid	29.8	40.50	42.2
6# R 4572	23.8	32.14	28.3
4# R 4572	19.7	18.96	10.5
L.S.D. 5%	8.1	11.84	

^{1/} Variety: Katahdin. Planted 7 June '63. Treatments applied 6 June '63.

^{2/} Duncan's Multiple Range Test, 5% level.

^{3/} Principal weed: Wild rutabaga.

WEED CONTROL IN YOUNG APPLE AND PEACH ORCHARDS

W. E. Chappell¹

Weed competition in young fruit trees is usually a very serious problem, and the weeds must be removed by some means if the trees are to make a normal growth. The usual method of weed removal is by means of a mechanical weeder that circles the trees. This is done two or three times per year. Such an operation often injures the roots and sometimes the stems of the young trees. In an effort to find suitable herbicides for weed control that would not injure the young peach and apple trees, preliminary experiments were initiated in 1961 and more extensive experiments were started in 1963.

MATERIALS AND METHODS

All herbicides were applied with a Spraying Systems $\frac{1}{2}$ " boomjet nozzle with OCO6 tips as a directed spray around the base of the young trees. The sprays were applied on all four sides to give double coverage as shown in Figure 1

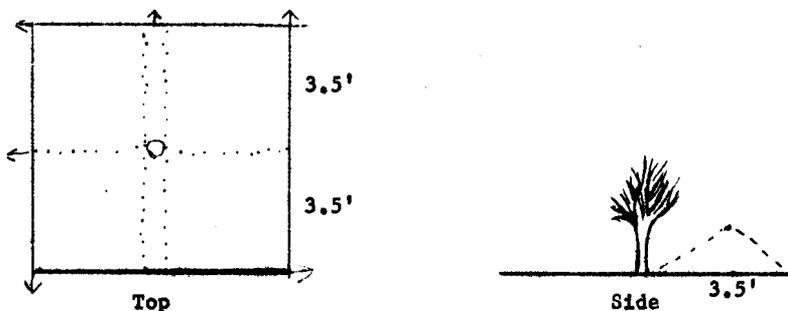


Figure 1 - Diagram of method of application of herbicides on all sides of the young trees.

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This method has proven to give more uniform coverage than by making a circle around the trees. An area 7 x 7 feet was sprayed around each tree for both peaches and apples. The chemicals used varied with each experiment and they are listed in the table with the results.

RESULTS AND DISCUSSION

Peaches

1962 Experiment. Four trees of newly set Sunhigh peaches were treated in May with the herbicides shown in Table 1. They were cultivated one time in August of 1962 but were not cultivated in 1963. All trees were mowed around in both 1962 and 1963 for weed and grass control. During the summer of 1962-63 the treated trees showed considerably more vigor than those that were not treated. It appeared that this increased vigor was due to some factor other than weed control but this could not be exactly determined from the design of the experiment.

Table 1. Effect of Certain Herbicides on the Growth of One Year Old Sunhigh Peach Trees, -- Treated in May, 1962

<u>Treatment/50 gal water</u>	<u>11/11/63 (Av. 4 trees)</u>		
	<u>Height (In.)</u>	<u>Spread (In.)</u>	<u>Caliper at base (In.)</u>
Simazine 3 + Amitrole 1	62.25	46.25	1.38
Simazine 3 + Amitrole 1 + 2,4-D 2	58.25	51.50	1.51
Simazine 3 + Amitrole 1 + 2,4-D 2 + Dacthal 10	62.25	56.25	1.38
Simazine 3 + Dalapon	54.75	44.50	1.15
Simazine 3 + Amitrol T 2	69.00	66.75	1.60
Dacthal 10 + Amitrol T 2	52.50	37.25	1.19
Trifluralin (liq.) 5	61.00	48.00	1.05
Paraquat 2 + Simazine 2	50.33	33.33	1.08
Paraquat 4	55.33	43.66	1.15
Dicamba 2 + 2,4-D 2	51.75	44.25	1.25
Check	47.88	32.75	0.97

1963 Experiments: Certain herbicides were applied to Blake peach trees at three locations on one year old peaches in the spring of 1963. In table 2 the chemicals used and results obtained at one location are shown.

Table 2. Effects of Cultivation and Herbicides on the Growth of Two Year Old Blake Peach Trees in the Northern Piedmont Area of Virginia

<u>Treatments in 50 gal. water</u>	<u>Average of 5 trees - 9/18/63</u>			
	<u>Av. Ht.</u> <u>In.</u>	<u>Av. Spread</u> <u>In.</u>	<u>Av. caliper</u> <u>In.</u>	<u>Weed</u> <u>Cont.</u>
Simazine 3 + Amitrole 1 + 2, 4-D 2#	83.0	75.0	1.73	10
Paraquat 1.5# + Diuron 3#	74.6	75.6	1.77	10
Shell 7961 in oil (1%) 25 gal + 25 gal water	72.6	73.0	1.70	8
Shell 7961 in oil (1%) 50 gal/A	77.6	77.6	1.73	8
Dalapon 10# + Simazine 3#	55.0	57.2	1.31	9
Paraquat 1.5# + Simazine 3#	70.6	66.4	1.67	8
Diuron 3# + Amitrol T 2#	63.5	64.75	1.47	9
Check (cultivated)	66.8	55.0	1.36	1
Check (not cultivated)	68.10	57.6	1.49	1

At this location one check was cultivated for weed control (three cultivations with rotary weeder) and the other check was left undisturbed. All herbicides except the dalapon-simazine mixture resulted in increased growth of the peach trees. The decreased growth caused by this mixture was evidently due to dalapon since simazine in other combinations did not result in a similar decrease. The cultivated check showed no more vigor than did the uncultivated check and it can be assumed that the increased vigor found in the herbicide treated trees was not due to weed competition alone.

At another location where the Blake variety was also used the results were similar as is shown in table 3.

Table 3. Effects of Certain Herbicides on Blake Peaches Set March, 1963 Treated 4/22/63

<u>Treatments (in 50 gal/water)</u>	<u>Average of 10 trees - 9/18/63</u>			
	<u>Av. Ht.</u> <u>In.</u>	<u>Av. Spread</u> <u>In.</u>	<u>Av. Cal. at</u> <u>base - in.</u>	<u>Weed</u> <u>Cont.</u>
Simazine 4.5 + Amitrole 1.5	61.17	46.17	1.34	9.0
H-82 6#	69.86	64.14	1.60	10.0
Diuron 3 + Amitrol T 2#	61.43	52.29	1.56	8.0
Simazine 3 + Amitrole 1.0 + 2,4-D 2#	61.17	53.17	1.50	9.0
Check	51.30	42.00	1.34	1.0

Here isocil (5-bromo-3-isopropyl-6-methyluracil) resulted in good weed control and caused no apparent damage to the trees at other locations and on first year trees this herbicide resulted in severe injury to peach and apple trees.

At a third location where one year old Madison peach trees were treated with various herbicides, isocil at six pounds per acre caused severe injury while three pounds mixed with two pounds of Amitrol T did not greatly injure the trees (table 4). Dalapon caused considerable injury to young trees at this location, also.

Table 4. Weed Control and Tree Vigor of Two Year Old Madison Peaches in the Southern Piedmont Area of Virginia

<u>Treatments (50 gal/A)</u>	<u>Average of 20 Trees - 7/12/63</u>	
	<u>Weed Control</u>	<u>Tree Vigor</u>
Simazine 3 + Amitrole 1 + 2,4-D amine 2#	8	9
Diuron 3 + Amitrol T 2#	8	9
Simazine 3 + Diquat 1.5#	8	9
Diuron 3 + Diquat 1.5#	8	9
Isocil (H-82) 6#	9	6
Isocil 3 + Amitrol T 2#	10	8
Dalapon 7 + Amitrol T 2#	7	7
Shell 7961 6# + Amitrol T 2	10	10
Check	1	7

Apples

1962 Experiments. Various herbicides were applied at several locations on newly set apple trees in the spring of 1962. The results of these experiments are summarized in table 5.

Table 5. Bonham - Chilhowie - First Year Apple Trees - Dwarf Red Delicious
Planted 4/15/62 - Treated 5/21/62 - 10 Trees Per Plot

<u>Treatments</u>	<u>Weed Control</u> <u>1/</u>		<u>Tree Vigor</u> <u>2/</u>
	<u>6/9/62</u>	<u>9/16/62</u>	
Amizine 7#	9.0	9.0	9.0
Amizine 7# + 2,4-D 2#	9.0	9.0	9.0
Diuron 2#	8.0	7.0	9.0
Diuron 2# + Amitrol T 2#	8.0	9.0	8.0
Paraquat 4#	1.0	1.0	6.0
Lorox 3#	9.0	9.0	9.0
Check	1.0	1.0	9.0

1/ 1 = No Control 10 = 100% Control
2/ 1 = Dead Trees 10 = Vigorous Trees

1963 Experiments. Four trees of each of five varieties of dwarf apple trees were treated at one location with eight herbicides or mixtures thereof (table 6). There was no indication that there was any differential varietal response to any of the treatments used on these one year old trees. Previous work has shown that golden delicious are somewhat more susceptible than other varieties when treated the first year after setting. Apparently the year old trees are less susceptible to injury. Isocil at 6 lbs caused a reduction of vigor on most trees in this experiment.

At another location dwarf red delicious trees that had been set just previous to treatment showed considerable injury from Isocil (table 7).

Table 7. Effects of Certain Herbicides on First Year Dwarf Red Delicious Apple Trees.

<u>Treatments</u> (50 gal/A)	<u>10/17/63</u>		<u>Plant Vigor</u> <u>6/20/63</u>	<u>Av. Weed Control</u> <u>6/20/63</u>
	<u>Av. Ht.</u> <u>(In.)</u>	<u>Av. Caliper</u> <u>(In.)</u>		
Simazine 3 + Amitrol 1	36.8	0.91	9	10
Diuron 3 + Amitrol T 2#	42.0	0.90	9	9
Paraquat 3 qts + Simazine 3#	44.2	0.90	9	8
Paraquat 3 qts. + Diuron 3#	44.5	0.88	9	9
Isocil 6#	32.1	0.85	5	10
Isocil 3# + Amitrol T 2#	32.6	0.84	8	10
Balance 10 + Simazine 2#	36.1	0.82	8	8

Table 6. Effects of Herbicide Treatments on Five Varieties of One Year Old Apple Trees

Treatments (50 gal/A)	Data taken 9/18/63													
	All Varieties				Double Red		Golden		Red		Vance		Imperial	
	Ht.	Cal.	Weed Control	Plant Vigor	Delicious		Delicious		Prince		Delicious		Delicious	
				Ht.	Cal.	Ht.	Cal.	Ht.	Cal.	Ht.	Cal.	Ht.	Cal.	
Simazine 4.5 + Amitrole 1.5	73.4	.86	8	9	69.50	.96	67	1.10	92	1.28	88	1.23	81.5	1.00
H-82 (isocil) 6#	66.8	1.06	10	5	63.50	.84	62.8	.84	78	1.20	81.5	.93	76.5	.95
Diuron 3# + Amitrol T 2#	72.0	1.01	9	8	69.25	1.00	67.8	1.00	90	1.18	80.8	1.19	72	1.03
Simazine 3 + Amitrole 1 + 2,4-D 2#	73.0	1.42	10	9	70.50	1.05	71.3	1.12	88.5	1.17	82.8	1.00	72.5	1.15
Shell 7961 4#	70.8	1.02	7	9	67.75	.98	69	1.11	83	1.10	75	1.07	85	1.20
Shell 7961 2# + Amitrol T 2#	73.8	1.13	8	9	73.25	1.46	67.3	1.21	78	1.01	84.3	1.14	81.5	1.12
Paraquat 3 qts + Simazine 3#	72.6	.86	7	9	70.75	1.00	72	1.04	92.5	1.03	82.3	1.11	80	1.10
Simazine 3 + Amitrole 1 + Dacthal 10#	69.3	.96	9	9	72.75	.97	67.3	1.04	76	1.03	75	1.00	72	.90
Check	66.9	.88	1	7	71.13	.92	69.4	1.00	76.5	.89	72.3	.96	71	.93

Ht. - Height in inches

Cal. - Caliper at base in inches

Isocil at 3 pounds plus Amitrol T also resulted in some tree injury at this location. This further emphasizes that first year trees are more susceptible than one year old trees.

Several herbicides were evaluated at three locations on newly set trees. The materials used and results obtained are shown in table 8. Isocil injured trees at all locations but none of the other chemicals showed any appreciable damage.

Table 8. Effects of Herbicides on Weed Control and Plant Vigor on First Year Apple Trees at Three Locations.

Treatments (50 gal/A 5/28/63)	Readings taken 7/15/63					
	A		B		C	
	Weed Control	Tree Vigor	Weed Control	Tree Vigor	Weed Control	Tree Vigor
Simazine 4.5 + Amitrole 1.5	8	9	9	9	8	9
Hyvar 6#	9	2	10	4	10	3
Diuron 3 + Amitrol T 2#	9	9	8	9	8	9
Simazine 3 + Amitrol 1	9	9	9	9	8	9
Shell 7961 4#	10	9	7	9	7	9
Shell 7961 4# + Amitrol T 2#	10	9	10	9	9	9
Paraquat 3 qts. + Simazine 3#	9	9	9	9	9	9
Simazine 3 + Amitrol 1	9	9	8	9	7	9
Check	1	3	1	8	1	7

SUMMARY AND CONCLUSIONS

Several herbicides or combinations thereof are apparently safe for use on young peach and apple trees. Certain chemicals result in increased growth of trees over and above that which would be expected from lack of weed competition alone. This phenomenon was more pronounced in peaches than in apples. First year peaches and apples are more susceptible to damage from herbicides than are one or two year old trees.

CONTROLLING WEEDS WITH DIURON UNDER APPLE TREES ON
MALLING VII ROOTSTOCKS

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Diuron is one of several herbicides now labeled for control of weeds under apple trees. However, the label states - "do not apply under dwarf or semi-dwarf trees". This is a precautionary statement since little information is available concerning the use of this herbicide under trees on dwarfing rootstocks. Since a number of growers in the Northeast now have apple trees on Malling VII rootstock there is a demand for information about the effect of diuron under trees on this rootstock.

Procedure

In 1962 at the University orchard, 5 trees each of Bancroft, Sandow, New York 4416-1, New York 4408-1 and New York 18387 on Malling VII rootstock planted in 1956 and grown under the sod mulch system of culture were available. The soil type is Woodbridge loam. On May 22, 1962 diuron was applied at 3.2, 6.4 and 12.8 lbs. of active ingredient per acre and 3.2 lbs. per acre plus Surfactant X77 at the rate of 2 quarts per 100 gallons of spray mixture. Single tree plots of each variety were randomized.

On May 6, 1963 these treatments were repeated except that Dupont Surfactant W.K. was substituted for X77. In addition, 5 trees of Ottawa 292, Jubilee, New York 16884, Ottawa 274 and Ruby on Malling VII rootstock planted in 1956 were treated for the first time.

All spraying was done with a 3 gallon compressed air sprayer. The herbicide was applied to a circular area 3 feet in radius from the middle of the trunk of each tree at the rates of 3/4 pint per tree.

The primary weeds were quack grass (*Agropyron repens* (L.), Beauv, Kentucky bluegrass (*Poa pratensis* L.), orchard grass (*Dactylis glomerata* L.), bent grass (*Agrostis alba* L.), sorrel (*Rumex acetosa* L.) and dandelions (*Taraxacum officinale* Weber).

Throughout 1962 and 1963 visual observations of the effects of the treatments on weed growth and on the apple trees was observed. The weed control scale used ranged from 0 for no control to 10 for complete control.

Results and Discussion

By July 5, 1962 it was apparent that good weed control was obtained from the diuron treatments applied on May 22, 1962 (Table 1).

Table 1. The Effectiveness of Diuron for the Control of Weeds Under Apple Trees on Malling VII Rootstock, University Orchard, Amherst, 1962 and 1963.

LBS. Diuron (A.I./A)	Trees Selected in 1962			Trees Selected in 1963
	Treated 5/22/62		Retreated 5/6/63	Treated 5/6/63
	Weed Control ^{x(z)} on 7/5/62	Weed Control ^{x(z)} on 5/6/63	Weed Control ^{x(z)} on 8/6/63	Weed Control ^{x(z)} on 8/6/63
3.2	8.6 ^a	8.2 ^a	9.7 ^a	2.6 ^a
3.2 †) 2 qts. of) Surf.Y)	8.8 ^a	8.4 ^a	9.4 ^a	3.8 ^a
6.4	9.3 ^b	10.0 ^b	10.0 ^a	6.9 ^b
12.8	9.8 ^c	9.9 ^b	10.0 ^a	8.6 ^b

^xVisual rating - 10 = 100% control; 0 = no control

^yColloidal Products Corp. Surfactant X77 used in 1962; in 1963 Dupont Surfactant W.K.

^zDifferences between treatments having the same letter are not significant.

The addition of surfactant X77 failed to increase the herbicidal activity of the 3.2 rate of diuron.

The weed control obtained with the May 22, 1962 treatments persisted until May 6, 1963 when the plots were retreated (Table 1). By August 6, 1963 the plots treated in May of 1962 and retreated in 1963 were practically free of weeds.

On the other hand, diuron except at the rate of 12.8 lbs. per acre failed to give satisfactory weed control under the trees treated for the first time on May 6, 1963. Eight days after treatment the addition of surfactant W.K. appeared to increase the herbicidal activity of diuron. However, the grass species gradually recovered and by mid-July the grass control at 3.2 lbs. of diuron per acre was no better with surfactant W.K. than without (Table 1).

Diuron at the rate of 3.2 lbs. per acre is the standard recommendation for Massachusetts. No injury was noted on trees of any variety in 1962 and 1963 even when 4 times the recommended rate was used for two consecutive years.

Diuron was applied at the rate of 3.2 lbs. per acre under McIntosh, Red Delicious and Cortland trees on Malling VII rootstock, ranging from 4 to 6 years in age in 4 grower orchards in 1962. In 1963, diuron was again applied at the same rate under 47 six-year old Puritan and Red Delicious trees in Malling VII rootstock in a grower orchard. No injury was noted to the trees of any variety.

In 1962 good weed control was obtained with 3.2 lbs. of diuron per acre at the University orchard in Amherst (Table 1). In 1963, on the other hand, unsatisfactory control was obtained at rates twice this amount in the same block of trees. Research with herbicides often has revealed some erratic results and some of the causes have been reviewed by Sheets and Danielson (1). Microbial action, volatilization, soil composition, leaching, chemical reaction, photo-decomposition and absorption by plants are all factors affecting the movement and persistence of herbicides in soils.

Summary

Diuron was applied under several numbered selections and varieties of apple trees on Malling VII rootstock to determine the effect on the trees. Concentrations at 4 times the standard recommendation (3.2 lbs.) for two consecutive years resulted in no observable injury to the trees of the varieties used.

Excellent weed control was obtained with diuron in 1962, whereas, except at the rate of 12.8 lbs. diuron failed to give satisfactory weed control in the same block of trees in 1963.

The addition of a surfactant failed to increase the herbicidal activity of diuron.

Literature Cited

1. Sheets, T. J. and L. L. Danielson. 1960. Herbicides in soils. ARS 20-9: 170-181.

WEED CONTROL AROUND YOUNG PEACH AND APPLE TREES
WITH SUBSTITUTED URACILS

V. J. Fisher¹

Preliminary studies in 1962 at the University of Delaware indicated that isocil² was promising for weed control in fruit. More extensive studies were made in 1963 to verify this finding, and to compare with isocil a closely related analogue, bromacil.

An orchard was set out at the University of Delaware Farm at Newark on March 26, 1963, for this research. A cover crop of spring oats was present when the trees were planted. The soil was Matapeake loam, a very productive soil. Treatments were applied in 200 gallons of water per acre to a circular area extending two feet from the trunks, on May 16, 1963.

Total rainfall from April through October was 13.87 inches.

The experiment consisted of three parts, as follows:

1. Isocil, bromacil, and the most promising herbicides now in use on fruit (see Table 1) were compared at the lowest rates that were thought to be effective. These were applied to Red Globe peach and Skyline Supreme / EM VII apple in a randomized block experiment containing five individual-tree replicates of each fruit for each herbicide treatment.

These treatments were repeated on the same trees on September 24, 1963, with these changes: the gallonage was reduced from 200 to 100; bromacil was used at 1 lb. instead of .5 lb., since the lower rate had proved to be inadequate; and ATA plus Simazine rates were modified slightly to conform to the rates at which they are combined in the proprietary material, Amzine.

2. Isocil and bromacil were applied to four varieties of peach at variable rates (see Table 2) in order to determine the margin of safety for these compounds. The varieties used were Red Globe, Loring, Elberta, and Cumberland. One tree of each was used for each rate.
3. Part 2 was duplicated on apple (see Table 2). The varieties used were Skyline Supreme / EM VII, Starkspur Golden Delicious / Clark, Law Red Rome / EM VII, and Blackjon / EM VII.

1. Assoc. Prof. of Horticulture, University of Delaware.
2. "Hyvar", Isocil Weed Killer, product of E. I. du Pont de Nemours & Co., Wilm., Del.

The results are shown in Tables 1 and 2. Isocil and bromacil at one pound per acre almost completely eradicated the existing cover crop of oats from the treated areas. They were superior for this purpose to all other chemicals tested at the rates used.

The germination and growth of new weeds through the summer was essentially nil where isocil or bromacil at one pound was used. The other chemicals were equally effective, except that dichlobenil¹ was slightly inferior.

One-half pound of bromacil was not sufficient to eradicate existing vegetation, or to maintain weed control through the season.

The growth of weeds that was present in the fall on plots that had been treated in May was essentially eradicated by both isocil and bromacil at one pound per acre. The other chemicals were equally effective, except that dichlobenil had almost no effect.

Peach was not injured by isocil or bromacil at any of the rates tested. No other chemical gave injury either, except for a temporary chlorosis or bleaching from ATA plus Simazine that is frequently observed where ATA has been used.

Apple showed temporary slight chlorosis from isocil at 4 and 8 pounds. Slight temporary injury occurred also where isocil was used at 2 lb. (but not at 1 lb.) and where bromacil was used at 1, 2, and 4 lb. (but not at .5 lb.); however, these symptoms were too slight to be definitely distinguishable as herbicide injury. The other chemicals gave no injury except for the same type of injury from ATA-Simazine that occurred on peach.

In addition to this main experiment, the following brief studies were made:

1. Peach trees that had been treated with isocil at 2, 4, and 8 lb. in 1962 were treated again in 1963 at the same rates. Slight injury was apparent in late summer on two of the three replicates at 8 lb. and on one of the three replicates at 4 lb. These trees were on a very light Sassafras sandy loam soil.
2. Isocil, at 2 lb., was applied around peach trees on three different dates in order to determine if large weeds would be killed by this rate of herbicide. The trees were in their second year in the orchard. Two important observations were made: first, if weeds approached the flowering stage before treatment, they usually were not killed; and second, if weeds were tall enough to cause parts of the peach trees to be sprayed, a rather severe chlorosis of the peach leaves occurred.

1. "Casoron" dichlobenil, product of Thompson-Hayward Chemical Co., Kansas City, Mo.

3. Isocil and bromacil were applied to peach seedlings and apple lining-out stock in the nursery row, in order to compare the phytotoxicity of the two chemicals. Treatments were applied June 5. Spray was directed uniformly over an area having a radius of two feet, deliberately spraying the lower portion of the trees to a height of 4 to 6 inches. Each circle contained 4 to 8 peach seedlings or apple liners. Injury ratings were made June 18. The mean injury ratings were as follows (0 = none to 10 = dead), indicating very little difference between the two chemicals in phytotoxicity to peach and apple.

		Peach			Apple		
	lb./A:	2	4	8	2	4	8
Isocil		3.9	6.6	8.9	3.4	3.0	4.7
Bromacil		2.8	8.2	8.3	4.4	2.8	5.2

CONCLUSIONS:

1. Isocil is promising for weed control around peach trees, by directed spray at one to two pound per acre where the weed growth is nil or consists only of seedlings up to three inches tall. The treatment apparently can be repeated when the herbicide level in the soil drops low enough to permit seedling weeds to survive.
2. Bromacil appears from limited studies to have essentially the same herbicidal activity on fruits as does isocil.
3. Apple is more sensitive to isocil and bromacil than peach. Further research is needed to determine whether these chemicals can be used safely on apple.

TABLE 1. Weed control obtained with several chemicals in 1963 on apple and peach, treated May 16 and repeated on September 24.

Chemical	lb/A, act.	Per cent of the ground around the trees that was covered by:						
		the cover crop 6/17	weeds 6/24	weeds 8/15	old weeds 9/24	new weeds 9/24	old weeds 11/4	new weeds 11/4
Isocil	1	4	0	3	15	10	4	2
Isocil	2	2	0	9	3	11	0	0
Bromacil	0.5 ⁽¹⁾	61 ⁽²⁾	0	9	31	12	11	3
ATA	2) ⁽³⁾	36	0	6	18	14	7	2
Simazine	4)							
Dalapon ⁽⁴⁾	5.4)	51	0	2	10	10	2	0
Diuron	2.4)							
Dichlobenil ⁽⁵⁾	4	25	0	6	26	35	23	28
Hoed check	-	100	30	28	51	16	32	72
Check, no weed control	-	100	24	66	77	19	66	50

No injury occurred except for temporary slight chlorosis or bleaching from treatment with ATA plus Simazine. This injury was observed on both apple and peach in early June. By early July, the affected leaves had fallen and the trees appeared to be normal. One replicate of this same treatment showed the same symptoms on November 4.

- (1) The rate was changed to 1.0 lb. on September 24.
- (2) See Table 2 for the effect of 1 lb/A.
- (3) The rate was changed to 1.5 lb. ATA plus 4.5 lb. Simazine on September 24.
- (4) This treatment was not applied to peach.
- (5) 1/4% of Thompson-Hayward's experimental surfactant NT 1 was added.

TABLE 2. Weed control and injury obtained with several rates of Isocil (I) and Bromacil (B) on newly planted apple and peach trees, treated May 16, 1963.

Date and item evaluated	Hoed check	1 lb/A		2 lb/A		4 lb/A		8 lb/A	
		I	B	I	B	I	B	I	B
6/17, % of ground covered by the cover crop	100	-	7	1	2	0	0	0	-
6/24, % of ground covered by weeds	81	-	0	0	0	0	0	0	-
8/15, % of ground covered by weeds	80	-	2	1	1	1	1	0	-
9/28, % of ground covered by old weeds	34	-	18	0	6	5	0	0	-
9/28, % of ground covered by new weeds	20	-	18	11	15	14	10	10	-
11/4, % of ground covered by old weeds	30	-	8	0	8	12	2	0	-
11/4, % of ground covered by new weeds	52	-	34	10	18	4	8	1	-
Injury to apple 7/9	-	-	T ¹	T	0.1	0.2	T	0.1	-

There was no injury to peach at any time, and the injury to apple noted above was not apparent on August 15 or thereafter.

1. T = trace, not definitely distinguishable as herbicide injury.

THE EFFECTIVENESS AT VARIOUS TIMES OF SEVERAL HERBICIDES
 COMPARED WITH DALAPON FOR GRASS CONTROL IN APPLE ORCHARDS¹

William J. Lord and G. Everett Wilder²

Several herbicides have been labeled for use in apple orchards and new materials are continually being introduced. Since the majority of apple orchards in Massachusetts are grown under the sod-mulch system of culture, a contact herbicide is used with a soil sterilant added to improve grass and broadleaf weed control. However, it has been suggested that some soil sterilants, if applied in late fall or before grass growth in the spring, will control established grass as well as broadleaf weeds.

The use of contact herbicides is generally recommended for use in the spring before the grass is more than 8 to 10 inches high (2, 3). Pest control is critical in the spring, however, and it may not be convenient for the orchardist to apply weed control materials at this time.

Since the addition of a surfactant to lesser amounts of herbicide may give the required grass control, it may be possible to reduce both damage to apple trees and the cost of the herbicide applications.

The experiments reported herein were conducted to (a) test the effectiveness of several labeled and new herbicides in comparison to dalapon when used at various times for grass control in apple orchards and (b) to determine if a surfactant will increase the activity of the herbicides.

PROCEDURE

The experiments were conducted in bearing apple orchards in Shelburne, Amherst, Belchertown and Leominster, Massachusetts. The weed population in the Leominster and Belchertown orchards was principally grasses - quackgrass (*Agropyron repens* (L.) Beauv), Kentucky bluegrass (*Poa pratensis* L.) and orchard grass (*Dactylis glomerata* L.). In the Shelburne orchard the grass cover was similar to this, but was generally light with many broadleaf species present. The principal broadleaf weeds were: common cinquefoil (*Potentilla canadensis* L.), dandelion (*Taraxacum officinale* L.), sorrel (*Rumex acetosa* L.), wild carrot (*Daucus carota* L.), ragweed (*Ambrosia artemisifolia* L.) and Lambsquarters (*Chenopodium album* L.). The dominant weed species in one Amherst orchard were quackgrass and Kentucky bluegrass and in another block in the same orchard - quackgrass, orchard grass, Kentucky bluegrass, sorrel and bindweed (*Convolvulus sepium* L.).

¹Contribution of the Massachusetts Agricultural Experiment Station, Amherst, Mass.

²Extension Pomologist, Department of Horticulture and Pioneer Valley Regional Agent, respectively.

The herbicides used for grass control, their concentration and time of application, are indicated in the tables. Rates of all herbicides are expressed as pounds per acre of active ingredient.

Single tree treatments were replicated 5 or more times in each orchard. The spray treatments in all trials were applied with a 3-gallon compressed air sprayer. Applications, with the one exception noted in the text, were made to a circular area 3 feet in radius from the middle of the trunk of each tree at the rate of 3/4 pint of spray per tree.

Visual observations were made throughout 1963 to determine the effects using a weed control scale that ranged from 0 for no control to 10 for complete control. A rating of 9.0 or higher was considered to be acceptable control by the authors.

RESULTS AND DISCUSSION

Late Fall and Early Spring Treatments

When the spray treatments were applied on October 16 and 17, 1962, the grass was 12-18 inches in height and still green. At the time of treatment on October 30 and 31, 1962, some browning of the grass was evident. The treatments on March 29, April 4 and April 5, 1963 were applied several days after the snow had left the orchards.

The data in Table 1 show that the late fall and early spring herbicidal treatments failed to give acceptable grass control.

Table 1. The Effectiveness of Several Herbicides When Used as Late Fall or Early Spring Applications for Grass Control.^a

Material and Rate (lbs. A.I./A.)	LOCATION & TIME OF TREATMENT						
	LEOMINSTER			SHELBURNE			AMHERST
	1962 10/10	1963 10/30	1963 4/5	1962 10/16	1963 10/30	1963 4/4	1963 3/29
	Grass Control ^b						
Diuron (3.2)	0.7	0.3	0.5	0.2	0.5	0.2	0.8
Diuron † (3.2) †	0.7	0.5	---	0.4	0.5	---	---
Surfactant (2 qts.) ^c							
Simazine, 80% W.P. (3.2)	1.5	0.5	0.1	0.0	0.4	0.0	0.2
Simazine, 4% Gran. (3.0)	5.2	3.5	0.2	4.0	1.3	0.1	0.0
Dalapon (8.5)	0.0	0.0	---	0.0	0.0	---	---

^aSingle tree treatments replicated 5-8 times.

^bVisual rating on July 22 & 24, 1963: 10 = 100% control; 0 = no control.

^cDuPont Surfactant W.K.

Granular simazine gave significantly better grass control than the other materials used in the fall. The effectiveness of the spring applications of granular simazine, simazine W.P., and diuron did not differ, however, Surfactant W.K. failed to increase the herbicidal activity of diuron.

In early May, 1963, dalapon appeared to have given excellent grass control while the effect of the other herbicides was hardly noticeable except for slight browning of the grass. However, by late May regrowth of the grass had occurred on the dalapon plots and the effect of the fall treatments of granular simazine was noticeable.

Dalapon is a systemic herbicide and moves readily throughout the plant system (4). It appears that translocation of dalapon to the underground parts of the grasses treated in the fall was not in sufficient quantity to prevent regrowth. On the other hand, Burrell (1) in New York reported good results with dalapon and diuron combination about October 20 when the grass was still green.

May Treatments

Diuron, simazine W.P. and granular simazine failed to control the established grass and broadleaf weeds (cinquefoil, sorrel, milkweed and dandelions) when applied in May in the Leominster, Shelburne and Amherst orchards (Table 2). Commercially acceptable grass control was obtained with dalapon at both the 4.25 and 8.5 lb. rates, however.

Table 2. Effectiveness of Several Herbicides for Grass Control Under Apple Trees, May 2 and 3, 1963^a

Material	Rate lbs. (A.I./A.)	Grass Control ^b		
		Leominster	Shelburne	Amherst
Diuron	3.2	0.0	0.0	0.0
Simazine, 4% Granular	3.0	0.0	0.0	0.0
Simazine, 80% W.P.	3.2	0.0	0.0	0.0
Dalapon	8.5	9.3	9.6	9.9
Dalapon	4.25	9.0	9.0	---

^aSingle tree treatments replicated 8 times.

^bVisual ratings on July 23 and 24: 10 = 100% control; 0 = no control

ACP (ACP-63-102) and amizine compared favorably with dalapon in two grass control trials conducted at Amherst (Table 3).

Table 3. Effectiveness of Several Herbicides in Comparison with Dalapon for Grass Control, May 9, 1963^a

Material	Rate lbs. (A.I./A.)	Grass Control ^b	
		Amherst I	Amherst II
Dalapon	8.5	9.9	9.2 ^d
Dalapon	4.25	---	3.8 ^d
Dalapon / Surfactant ^c	4.25 / 2 quarts	---	3.9 ^d
Amizine	1.05 amitrole / 3.15 simazine	9.9	9.2
Cytrol	2 amitrole / 2 ammonium thiocyanate	4.1	2.1
ACP-63-102	2 amitrole / 4 simazine	9.8	9.5

^aSingle tree treatments replicated 8-10 times in each orchard.

^bVisual rating on July 21 and 22: 10 = 100% control; 0 = no control.

^cDuPont Surfactant W.K.

^dCircular area 12 feet in diameter sprayed with 3 pints of solution.

Cytrol applied at the rate of 2 lbs. of amitrole and 2 lbs. of ammonium thiocyanate per acre failed to give satisfactory grass control while the two commercial mixtures containing amitrole and simazine provided better than 90% grass control. Amizine, ACP and cytol failed to eliminate all dandelions, sorrel and milkweed or any bindweed.

ACP and amizine would be especially valuable if applied just prior to petal fall in bearing apple orchards having poison ivy in addition to grass and broadleaf weeds. Although ACP and amizine may not give complete control of poison ivy with this timing, the use of these herbicides should help prevent the rapid influx of this weed in the area where grass has been controlled.

With herbicides, definite conclusions from the results of one year are not warranted. However, unpublished data obtained by the authors in 1962 support the figures in Table 3 showing that amizine or dalapon at the rates used gives better grass control than cytol.

It can be seen in Table 3 that dalapon at the rate of 4.25 pounds per acre failed to give satisfactory grass control in Amherst orchard II although the results were satisfactory in the Leominster and Shelburne orchards (Table 2). The trees at Leominster and Shelburne were 20 years of age and older and the grass was less vigorous under these trees, due to the shading effect of the tree limbs, than under the 5 year old trees at Amherst. In addition, more orchard grass was present in the Amherst orchard and this species of grass appears to be more difficult to control with the herbicides used than quackgrass and Kentucky bluegrass. Curtis (3) in New York has reported that dalapon applied at the rate of 4.25 pounds per acre sometimes fails to give season-long control of grass so repeat applications are necessary.

The data in Table 3 show that surfactant W.K. failed to increase the herbicidal activity of dalapon in Amherst orchard II.

June Treatments

The applications of diuron and simazine applied on June 25, 1963 on plots that had been previously mowed, failed to control established grass, whereas dalapon gave considerable control (Table 4).

Table 4. Effectiveness of Several Herbicides With and Without a Surfactant for the Control of Grass after Mowing in June^v

Herbicide	LBS. (A.I./A.)	Grass Control ^w (9/4/63)		
		Chemical Without Surfactant	Chemical With Surfactant ^x	Average Control With or Without Surfactant
Diuron	3.2	0.57	2.43	.857 ^{a(z)}
Simazine, W.P.	3.2	0.41	1.57	1.500 ^a
Dalapon	4.25	8.21	9.07	8.642 ^b
		----	----	
	Avg. Control	2.976 ^{a(z)}	4.357 ^b	

^vGrass mowed on June 12, 1963; single tree treatments replicated 7 times on June 25 when grass was 6-8 inches in height.

^wVisual ratings: 10 = 100% control; 0 = no control.

^xTrimethyl Nonyl Ether of Polyethylene Glycol (Product of Union Carbide) - 2 quarts/100 gallons of water.

^zDifferences between treatments having the same letter are not significant.

The surfactant significantly increased the herbicidal activity of the herbicides. However, a separate test for significance showed that it failed to increase the activity of dalapon.

July Treatments

The comparative effectiveness of paraquat and dalapon for grass control when applied on July 10, 1963 is shown in Table 5.

Table 5. The Effectiveness of Paraquat in Comparison with Dalapon for Grass Control^x

Herbicide	LBS. (A.I./A.)	GRASS CONTROL ^y (9/4/63)
Paraquat	1 1/2 active cation	6.900 ^{a(z)}
Paraquat	3 active cation	8.300 ^b
Dalapon	8.5	9.680 ^c

^xGrass mowed in late June. Single tree treatments replicated 5 times on July 10, 1963 when the grass was 6 - 10 inches in height.

^yVisual ratings: 10 = 100% control; 0 = no control.

^zDifferences between treatments having the same letter are not significant.

Significantly better grass control was obtained with 3 lbs. active cation of paraquat than with 1 1/2 lbs. of paraquat; dalapon gave significantly better grass control than either concentration of this material.

The apparent control of grasses and broadleaf weeds with paraquat was striking within 2 days after treatment. On the other hand, the effect of dalapon on the grass was only slightly evident 5 days after treatment.

The dalapon and paraquat treatments gave almost perfect grass control for at least a month but regrowth of broadleaf weeds such as plantains and buttercups occurred on all plots. By September, however, more grass regrowth had occurred on the paraquat treated plots than those treated with dalapon.

Limbs on a bearing Baldwin, Delicious and McIntosh tree were purposely sprayed with paraquat. The herbicide caused defoliation followed by severe injury to the fruit and abnormal fruit color development.

SUMMARY

Several herbicides were used at various times during 1962 and 1963 to determine their effectiveness in comparison to dalapon for grass control in apple orchards.

Soil sterilants - diuron, simazine, 80% W.P. and 4% granular simazine were found ineffective for control of established grass when applied in late fall, early spring before grass growth occurred, or when the grass was actively growing.

Applications of dalapon applied in late fall failed to control grass, but were effective when applied during May, June and July. Dalapon applied at the rate of 4.25 pounds failed to give acceptable control in some instances (90% control or better).

ACP-63-102 and amazine compared favorably with dalapon for grass control. ACP-63-102 and amazine, which are commercial mixtures containing amitrole and simazine, were significantly more effective for grass control than cytrol which contains amitrole and ammonium thiocyanate.

The addition of a surfactant failed to give a consistent increase in herbicidal activity.

Preliminary trials with paraquat indicate that further testing of this material is warranted.

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**CONTROLLING POPLARS, POPULUS TREMULOIDES, MICHX.,
AND P. GRANDIDENTATA, MICHX. IN LOWBUSH BLUEBERRY FIELDS WITH FENURON**
J. S. Bailey¹, W. J. Lord¹, and G. E. Wilder²

Wild lowbush blueberry fields of Massachusetts are infested by various weed species. Among these are two species of poplar, Populus tremuloides, Michx. and P. grandidentata, Michx., which frequently become a serious pest. They multiply rapidly because of their habit of sprouting both from the old stump and from the roots following mowing which the grower practices every two or three years. A thick stand of poplars makes harvesting the berries by raking difficult or impossible.

Poplars have been controlled successfully with 2,4,5-T in water or oil (1,2) but this has some disadvantages. It requires the use of considerable quantities of water or oil. Unless the spraying is carefully done, large patches of blueberries may be killed. Fenuron (Dybar) pellets³ seemed to offer the possibility of doing a very satisfactory killing job with less labor (1). Therefore, this work with fenuron (Dybar) was undertaken.

In the fall of 1961, thirty square rod plots were laid out in a grower's field in Granville, Mass. All plots were heavily infested with poplars, mostly P. tremuloides. Half the plots were treated in late September 1961 and half in April 1962 with fenuron (Dybar) pellets. Broadcast applications were made at rates of 20,40 and 60 lbs. per acre, one plot each. Individual stem treatments were made at rates of 1/2, 1, and 2 teaspoons per stem. There were four replications of the stem treatments in both fall and spring. Stem counts of poplars were made on all plots before and after treatment. On August 14, 1963 the percentage stand of blueberry plants was estimated. The results are given in Tables 1 to 4. Since the amount of kill of poplars was the same following fall or spring stem treatments, the data were combined.

Table 1. Percentage kill of poplars following individual stem applications of fenuron.

Rate per stem	No. stems before treatment	No. stems after treatment	Per cent kill
1/2 tsp.	1243	5	99.6
1 "	1168	0	100.0
2 "	1056	0	100.0

Obviously, 1/2 teaspoon per stem was sufficient to give a satisfactory kill of poplars.

Although the kill of poplars was very satisfactory, the effect on the

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³The Dybar was supplied by the E. I. DuPont Co.

blueberry was not (Table 2). The number of poplar stems per square rod varied from 53 to 358 with 25 of the 30 plots having over 100. Because of this large number of stems, the amount of fenuron per plot was much too heavy.

Table 2. Estimate of stand of blueberry plants on August 14, 1963 following fall and spring applications of fenuron.*

Rate per stem	Time Applied		Mean
	Fall	Spring	
1/2 tsp.	2.00	3.50	2.75
1 "	1.25	2.75	2.00
2. "	1.25	2.00	1.62

* 0 = no plants; 10 = full stand

Apparently, the spring applications were less harmful than those made in the fall, but both were too injurious to the blueberry plants. Nevertheless, the blueberry plants are not all dead. There is evidence of regrowth and hopefully, the plots will be recovered with blueberries in a few years.

The use of broadcast applications resulted in slightly poorer poplar control (Table 3), but were much less injurious to the blueberry plants (Table 4) than the poplar stem treatments.

Table 3. Control of poplars in lowbush blueberries following spring and fall broadcast applications of fenuron.

Rate lbs. per acre	Fall			Spring			Fall and Spring		
	No.stems per plot at start	No.stems '8/14/63 'con-	% 'trol	No.stems per plot at start	No.stems '8/14/63 'con-	% 'trol	No.stems per plot at start	No.stems '8/14/63 'con-	% 'trol
20	184	50	72.0	162	96	40.7	346	146	57.8
40	222	42	81.1	222	62	73.0	444	104	76.6
60	169	20	88.2	207	5	97.6	376	25	93.4

Table 4. Estimated stand of blueberry plants on August 14, 1963 following fall and spring broadcast applications of fenuron.*

Rate lbs. per acre	Time Applied	
	Fall	Spring
20	9.5	10.0
40	9.5	9.5
60	8.5	9.5

* 0 = no plants; 10 = full stand.

Among broadcast applications there appeared to be very little, if any, difference in effect on the blueberry plants produced by time or rate of application.

Discussion and Conclusions

The control of poplars by the individual stem treatment method must be used with care. One-half teaspoon per stem was adequate for control of poplars which were about two to four feet in height. However, this small amount on a large number of stems on a limited area can result in an excessive amount followed by severe injury to the blueberries.

The use of a broadcast application appears to be more promising. None of the applications seriously reduced the stand of blueberries. The 60 pound rate applied in the spring gave best poplar control. The 15 per cent reduction in stand of blueberries is not serious, considering the benefits gained.

It was observed that in numerous instances poplars outside the treated plots were dead. This suggests that the effect of fenuron was transferred along the roots so that two or more stems were killed by an application to a single stem.

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FALL TREATMENT FOR CLEAN SOIL IN SPRING

A. M. S. Fridham¹

Many nursery crops remain in the lining out area or field for 3 years or more in one location. Presumably such nursery stock is planted in weed-free soil and is weeded in summer to remove vegetative parts of perennial weeds. The last weeding and clean up by October in New York State.

Effective control of seed or seedlings can be realized in fall by using herbicides on weed-free soil prior to weed seed germination or during the early stages of germination when soils are moist from fall rains or irrigation and conditions for germination are appropriate. Nursery crops are dormant and free of young foliage by late September; hence crop injury is less likely than from herbicide contact in spring.

With the elimination of perennial weeds, particularly quackgrass and artemisia, before planting and through spot weeding during the summer, spring operations including sale of nursery stock, planting, fertilizing and pest control can proceed effectively without unnecessary temporary labor or unnecessary disturbance of young plants during active growth of May and June. Crop damage from hoeing and cultivating is reduced and quality improved.

Many herbicides have been tested as spray or granular formulations applied in October-November by banding and leaving the inter-row space free of herbicide for cover crop or other conservation practice.

Granular formulations now in use 5 years or more include:

CIPC	8 lb. aia	test and practice
Dinitro	4 lb. aia	test
Diuron	2 lb. aia	test and practice
Neburon	8 lb. aia	test

Directional spray:

Amizine	2 lb. aia	test
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Recent additions, 2 year test:

Casaron, granular	5-10 lb. aia
CIPC-IPC, granular	8 lb. aia
Weed Beads, PCP, granular	40 lb. aia

Perennial weeds that invade areas following elimination of seedling weeds:		
Agropyron repens L.		from stolon sections, possibly seed
Artemisia vulgaris L.		"
Convolvulus arvensis L.		usually from seed
" sepium L.		"
Cyperus esculentus L.		usually from underground parts
Equisetum arvense L.		"

Care needs to be taken to prevent infestation from nursery stock set out bare root or potted. Care is necessary to clean weed parts from cultivation equipment, between and within fields or plant rows.

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Summer weeds of significance in nursery plantings:

Annual grasses:

Digitaria sanguinalis (L.) Scop.
Echinochloa crusgalli (L.) Beauv.
Setaria viridis (L.) Beauv.

Broadleaf:

Amaranthus retroflexus L.
Chenopodium album L.
Galinsoga ciliata (Raf.) Blake
Portulaca oleracea L.

Fall weeds as seedlings:

Anthemis cotula L.
Barbarea vulgaris R. Br.
Poa annua L.
Stellaria media (L.) Cyrill.

Others:

Mollugo verticillata L.
Oxalis stricta L.

CIPC has little if any effect on the perennial weeds noted except to retard young growth where sprays are used but granular formulations on moist soils will aid in reduction of many summer annuals except *Chenopodium album* and *Senecio vulgaris*. CIPC-IPC is effective on more weed species.

Dinitro granular has better residual weed control but its volatility and contact action on young crop foliage requires care in application. Avoid moist foliage and warm humid, foggy weather.

Diuron, 2 lb. aia granular, has been effective in fall and useful in spring for control of many summer annual weeds. A second application is necessary but can control summer weeds through spring treatment after hoeing. Late June or July treatment is preferred.

Neburon, 8 lb. aia, has not been followed up for control of summer weeds largely because Diuron is effective, available and widely used in the grape industry without significant crop injury from continued use.

Amizine, 2 lb. aia, as a directional spray, is effective on seedling weeds and young growth of quackgrass. The amino triazole yellowing is likely if leaf spray contact is made. The Amizine 2 lb. area level is not adequate for more than spot treatment of young seedlings of perennial weeds. The 5 lb. aia level is within late summer tolerance for some evergreens and effective for inrow treatment of quackgrass.

Casaron, granular, 5 lb. aia-10 lb. aia, two year's results indicate excellent control of quackgrass and of other weeds through May to June when seedling summer weeds appear. Nursery crops have not been injured from fall granular applications. Summer use is less impressive.

Weed Beads, used as granules, are preferred to their use in water as a spray because the sharp contact action of the spray injures nursery crops as well as the weeds. Residual effect of the granule has been greater than with the others noted to date for the purpose of weed control in woody ornamentals.

Chemical Weed Control in Transplanted

Annual Flowers

C. Haramaki and R. P. Meahl¹

Display beds in parks, institutional grounds, etc. have been normally kept clean by hand weeding. This is not only tedious but expensive. In recent years the use of pre-transplant herbicides has eliminated much of this, but their use has not been rapidly adopted. This is undoubtedly due to the lack of plant tolerance information of these herbicides. In this experiment we have included some chemicals which in the past have given satisfactory weed control with a minimum of injury to the flowers and added others which appear promising. The flowers tested included some from past experiments as well as some untested species.

Methods and Materials

The soil, which was Hagerstown silt loam, was disced several times and meekered prior to herbicide treatment. On June 25, 1963 the pre-transplant chemicals were sprayed on the soil and immediately incorporated by rototilling. The air temperature was in the low 90's and the soil temperature two inches below the soil surface was in the 80's. Each herbicide plot was 400 square feet in size and replicated five times. The annual flowers were transplanted on July 5, 1963 which was ten days after treatment. Sixteen different species of annual flowers were tested.

Results and Discussion

The plots were checked for weed prevalence on September 3, 1963 and the results are summarized in Table 1. The plots treated with Stauffer R-1607, Stauffer R-4572, and EPTC at 7 1/2 pounds per acre, trifluralin at 2 pounds per acre, and dichlobenil and Shell SD-7961 at 3 pounds per acre had excellent weed control ten weeks after application.

On September 6, 1963 the plants were examined for injury. This is summarized in Table 2. Some plants such as plumed and crested celosia exhibited severe injury regardless of treatment while others such as petunia showed little or no injury also regardless of treatment. Plants which were tolerant of dichlobenil also were tolerant to SD-7961. Plants which were injured by one were injured by the other. This same pattern was also noticed with EPTC, R-1607 and R-4572. The plants in general were quite tolerant to trifluralin at the rate used. The injury caused by dichlobenil and SD-7961 is characterized by browning of the leaf tips and margins. The EPTC, R-1607, and R-4572 susceptible plants had either distorted or aborted buds. Scarlet sage also exhibited a blackening of the leaf margins and interveinal areas. Defoliation and eventually death were noticed on some

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Table 1. Effect of Pre-Transplant Herbicides on Weed Prevalence, Ten Weeks after Treatment, 1963.

Herbicide	Weed Prevalence	Weeds Present in Decreasing Frequency
R-1607 7½ #/A	0.2	Canada thistle, yellow foxtail, common ragweed, field peppergrass, Pa. smartweed, wild carrot.
EPTC 7½ #/A	0.4	Canada thistle, Pa. smartweed, field peppergrass, common ragweed, shepards-purse, common lambs quarter, buckhorn plantain, wild carrot, common mallow
Trifluralin 2 #/A	0.4	Canada thistle, field peppergrass, wild carrot, common ragweed, yellow foxtail, shepardspurse, common ragweed, Pa. smartweed.
Dichlobenil 3 #/A	0.6	Yellow foxtail
R-4572 7½ #/A	0.8	Canada thistle, yellow foxtail, field peppergrass, tumble pigweed, Pa. smartweed, common ragweed, purslane, red root pigweed, yellow rocket, rough cinquefoil.
SD-7961 3 #/A	0.8	Yellow foxtail, canada thistle, yellow rocket, shepardspurse.
Check	8.0	Yellow foxtail, Pa. smartweed, canada thistle, tumble pigweed, common ragweed, fall panicum, field peppergrass, shepardspurse, oxalis, black bindweed, purslane, wild carrot, wild mustard, red root pigweed, milkweed.

Weed Prevalence

0 = No Weeds
10 = 100% Weed Coverage

Table 2. Effect of Pre-Transplant Herbicide Treatments on Annuals which were Transplanted Ten Days After Treatment, 1963.

Plant	EPTC	R-1607	R-4372	Dichlo- benil	SD-7961-	Triflur- alin	Check
Amaranthus	1.85	1.15	1.50	2.15	2.00	2.4	1.90
Aster	1.51	1.13	1.79	2.50	2.76	1.19	1.01
Balsam	1.07	2.40	0.20	1.33	1.27	0.40	0.40
Celosia, crested	3.75	4.55	2.85	4.55	4.55	4.80	3.20
Celosia, plume	5.00	5.00	5.00	5.00	5.00	3.95	5.00
Coleus	3.65	3.70	2.05	1.80	1.60	1.15	0.90
Dahlia	0.40	0.55	0.65	2.10	2.80	0.20	0.35
Marigold	0.32	0.57	0.50	1.75	1.53	0.30	0.60
Marigold, Dwarf	0.55	0.63	0.73	2.80	1.90	0.60	0.68
Ornamental pepper	3.95	2.05	0.70	0.35	0.60	0.15	0.30
Petunia	0.72	0.35	0.39	1.14	0.78	0.48	0.39
Scarlet Sage	4.05	3.90	3.20	1.85	1.70	0.15	0.15
Snapdragon	1.65	0.80	0.10	3.65	3.70	0.10	0.00
Snapdragon, Dwarf	1.20	0.95	0.40	4.65	3.90	0.25	0.30
Zinnia	2.35	2.04	2.25	3.48	4.01	1.94	1.79
Zinnia, Dwarf	1.15	0.75	1.75	2.50	3.15	0.20	0.10

Plant Injury

0 - None
5 - Dead

plants. Snapdragons and dwarf snapdragons initially had malformed axillary buds, but after a few weeks the buds had formed into normal appearing stems, leaves and flowers. The exceptionally dry summer caused some crop injury in all treatments including the check plots.

Summary

Sixteen species of annual flowers were transplanted into soil which had been treated with six herbicides. Excellent weed control was obtained when EPTC, R-1607, or R-4572 at 7 1/2 pounds per acre, trifluralin at 2 pounds per acre, or dichlobenil or SD-7961 at 3 pounds per acre was incorporated in the soil.

Plants, which were injured or tolerant to dichlobenil, exhibited a similar response to SD-7961. This was also noted with plants which were transplanted in soil treated with either EPTC, R-1607 or R-4572. The annual flowers showed little or no injury when transplanted in trifluralin treated soil.

EVALUATION OF CERTAIN HERBICIDES ON SMALL
WOODY AND HERBACEOUS ORNAMENTAL PLANTS

R. A. Rosengren, C. W. Dunham, and E. M. Rahn¹

There exists a need for effective and safe herbicides on a wide spectrum of small nursery liners and herbaceous plants. Several are now in use on established nursery stock. Simazine is the one most widely used. However, on small plants of many species, Simazine has caused some injury. The following experiment was set up to evaluate several commonly used and experimental herbicides, for use on several nursery liners in both fall and spring applications, using a logarithmic sprayer.

Materials and Methods

Plant material was of lining-out size set in rows 5 feet apart, 50 feet long, with the plants 18 inches apart. The plantings and herbicide applications were made at two seasons, fall 1962 and spring 1963. Blocks 1 and 2 were planted and treated in the fall of 1962 and blocks 3, 4, and 5 were planted and treated in the spring of 1963. Fall plantings were made as follows: Peonies, Oct. 4; Taxus, Oct. 11; and Roses, Nov. 28, 1962. Herbicides were applied Nov. 30, 1962.

Spring plantings were made April 1 through 4, 1963. Herbicide application was delayed until May 16, because of difficulty in establishing the plants. Species used were:

Chamaecyparis pisifera plumosa obtusa

Hedera helix

Ilex crenata, var. Green Island

Ilex opaca

Peony, various hybrid seedlings

Rose, var. Pink Peace

Taxus media

Taxus X media F. Hatfield

Thuja occidentalis pyramidalis

The soil was a Chester silt loam, high in colloidal matter. The experimental area had been in sod for several years and a fairly high weed population had built up. A number of weed species were present. The following list is grouped according to severity of infestation, from heavy down to a few scattered individual plants.

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<u>Common Name</u>	<u>Scientific Name</u>
Flower-of-an-Hour	<u>Hibiscus trionum</u>
Water Smartweed	<u>Polygonum punctatum</u>
Pennsylvania Smartweed	<u>Polygonum pennsylvanicum</u>
Ragweed	<u>Ambrosia artemesiifolia</u>
Lambsquarter	<u>Chenopodium album</u>
Yellow Foxtail	<u>Setaria leutescens</u>
Common Crabgrass	<u>Digitaria sanguinalis</u>
Yellow Nutgrass	<u>Cyperus esculentus</u>
Hedge Bindweed	<u>Convolvulus sepium</u>
Common Morningglory	<u>Ipomea purpurea</u>
Ivy-leaved Morningglory	<u>Ipomea hederacea</u>
Fall Panicum	<u>Panicum dichotomiflorum</u>
Horse Nettle	<u>Solanum carolinense</u>
Indian Mallow	<u>Abutilon theophrasi</u>
Husk Tomato	<u>Physalis pubescens</u>
Night Shade	<u>Solanum nigrum</u>

Herbicides were applied with a logarithmic sprayer at 60 lbs. psi in 200 gallons of water per acre. Treatments of herbicides at various rates were replicated twice in completely randomized blocks, (Table I).

Table I. Rates of Herbicides Applied

<u>Herbicide and Formulation</u>	<u>Lb./A. Original Conc.</u>	<u>Lb./A. Peak Conc.</u>	<u>Lb./A. End Point Conc.</u>
Amiben ec	20	18.8	.7
Casoron wp	15	14.1	.5
Dacthal wp	30	28.2	1.0
Diphenamid wp	20	18.8	.7
R - 1607 ec	20	18.8	.7
Simazine wp	10	9.4	.3
Tillam ec	20	18.8	.7
Trifluralin ec	20	18.8	.7
Simazine (constant) plus Diphenamid	2.0 20	2.0 18.8	2.0 .7

Herbicides were applied overall in a 4 foot wide spray pattern centered over the rows after the plants had been planted in both fall and spring.

Rainfall before and after fall treatments was as follows:

November - Total rainfall 6.46 inches
Treatments Nov. 30 (followed by 1.50 inches of rain Dec.6)
December - Total rainfall 2.60 inches

Rainfall before and after spring treatments was as follows:

May - Total rainfall 2.20 inches

Treatments May 16 (followed by 1.10 inches of rain May 18)

June - Total rainfall 3.06 inches

Evaluation of the effectiveness of the various herbicides was by means of visual observation. Ninety per cent control of broadleaf weeds and grasses was accepted as satisfactory control. The amount of herbicide needed to obtain this was measured by the following methods. The row length was calibrated as Lbs./A. in 1 foot gradations on a logarithmic curve. The rate of chemical applied at the point where 90% control occurred was then read from the calibrated scale and recorded as the minimum effective rate of application.

Results and Discussion

None of the herbicides, even at the highest rates tested, injured the liners or plants of any ornamental species used in this experiment. Possibly, plants receiving herbicides in the fall may have been dormant at the time of application and little or no chemical was absorbed by the roots. Also, rainfall may not have been sufficient to carry herbicides down to the root zone. By spring when the plants resumed growth the herbicides may have been at least partially dissipated. Another factor which may have contributed to lack of injury was the high colloidal content of the soil which may have prevented movement of the herbicide down to the root zone. Again in the spring rainfall was extremely low for a long period and herbicides may not have reached the rooting zone of the liners.

The two outstanding treatments with regard to effectiveness and duration of weed control were Simazine and Simazine in combination with Diphenamid, (Tables II and III). Simazine alone gave full-season weed control from a spring application of 3.0 lb./A. Simazine alone applied in the fall at 5.8 lb./A. controlled weeds the following winter, spring, and summer. A fall application of Simazine plus Diphenamid (2.0 plus 4.0 lb./A.) also controlled weeds the following winter, spring, and summer. For full-season control from a spring application of Simazine plus Diphenamid 2.0 plus 4.0 lb./A. was required.

Although not indicated by the results of this experiment, which was conducted on a heavy soil type, the combination of Simazine at the relatively low rate of 2.0 lb./A. plus Diphenamid at 4.0 lb./A. might be expected to cause less injury on lighter soil types than Simazine used alone at higher rates.

Table II - Rates of Herbicide Needed for Weed Control 7, 3, 10 Months After Fall Applications

Herbicide	Max. Rate Applied ²	Minimum Rate Required for Control					
		6/28/63, after 7 months		7/25/63, after 8 months		10/1/63, after 10 months	
	Lb./A.	Ann.Gr. Lb./A.	Ann. Blvs. Lb./A.	Ann.Gr. Lb./A.	Ann.Blvs. Lb./A.	Ann.Gr. Lb./A.	Ann.Blvs. Lb./A.
Amiben	18.8	7.2	7.0	NC ³	NC	NC	NC
Caseoron	14.1	7.6	3.1	10.0	4.4	NC	NC
Dacthal	28.2	2.9	NC	5.2	NC	NC	NC
Diphenamid	18.8	4.2	NC	5.1	NC	NC	NC
Simazine	9.4	2.5	2.2	3.0	2.7	5.8	3.0
Tillam ¹	18.8	NC	NC	NC	NC	NC	NC
Trifluralin ¹	18.8	3.8	3.8	3.8	4.0	6.1	11.3
Simazine, 2 lb/A. (constant) Plus							
Diphenamid	18.8	0.7	0.7	2.0	2.0	4.0	4.0

¹ Herbicide was soil-incorporated 2 inches with rototiller.

² Small plants of previously listed species were not injured by maximum rate of any herbicide.

³ No Control - plots clean cultivated after 7/25/63 ratings.

Table III - Rates of Herbicide Needed for Weed Control 1½, 2½, and 4½ Months After Spring Applications

Herbicide	Max. Rate Applied ²	Minimum Rate Required for Control					
		6/28/63, after 1½ months		7/25/63, after 2½ months		10/1/63 after 4½ months	
		Ann.Gr. Lb./A.	Ann.Blvs. Lb./A.	Ann.Gr. Lb./A.	Ann.Blvs. Lb./A.	Ann.Gr. Lb./A.	Ann.Blvs. Lb./A.
Amiben	18.8	3.0	8.0	5.0	5.0	7.3	12.0
Casoron	14.1	3.5	2.8	7.1	6.0	NC ³	NC
Dacthal	28.2	3.0	NC	6.0	NC	NC	NC
Diphenamid	18.8	2.0	NC	3.0	NC	NC	NC
R - 1607	18.8	.7	5.0	2.0	14.0	5.1	5.1
Simazine	9.4	1.5	1.5	3.0	3.0	3.0	3.0
Tillam ¹	18.8	3.5	NC	7.0	NC	NC	NC
Trifluralin ¹	18.8	1.5	3.5	2.0	8.0	6.2	8.2
Simazine, 2 lb/A. (constant) Plus Diphenamid	18.8	.7	2.0	2.0	3.0	4.0	4.0

¹Herbicide was soil-incorporated 2 inches with rototiller.

²Small plants of previously listed species were not injured by maximum rate of any herbicide.

³No Control - plots clean cultivated after 7/25/63 ratings.

The only other herbicide in fall applications that gave full-season control the following year was Trifluralin at 11.3 lb./A.

Casoron in either fall or spring applications provided control through July 25, 1963.

Dacthal and Diphenamid in fall or spring applications provided good control of grasses, but not broadleaf weeds, through July 25, 1963.

In spring applications, other herbicides that gave full-season control were Stauffer R-1607 at 5.1 lb./A., Trifluralin at 8.2 lb./A., and Amiben at 12.0 lb./A.

The weed species present reacted differently to the herbicides. The most difficult weed to control was Flower-of-an-Hour which was prevalent throughout all the plots. Only the highest rates of Simazine, Simazine plus Diphenamid, Amiben, R-1607 and Trifluralin reduced the stand to any extent. Rag-weed and lambsquarter were tolerant to Dacthal and Diphenamid.

Conclusions

No injury to any of the species tested was observed at any rate of any herbicide applied. From the results of the effectiveness and duration of weed control in the various tests, the following treatments are suggested for weed control in the nursery liners tested:

Fall applications of:

Simazine - 4.0 lb./A.

Simazine plus Diphenamid 2.0 plus 4.0 lb./A.

Spring applications of:

Simazine - 4.0 lb./A.

Simazine plus Diphenamid - 2.0 plus 4.0 lb./A.

Amiben - 6.0 lb./A.

Trifluralin (soil-inc.) - 6.0 lb./A.

R - 1607 (soil-inc.) - 6.0 lb./A.

Casoron - 8.0 lb./A. for short duration control of
4 - 6 weeks.

The best results based on the number of weed species controlled for the longest period of time, were obtained with Simazine 4.0 lb./A. alone and Simazine plus Diphenamid, 2.0 plus 4.0 lb./A., applied in the fall. The other herbicides tested above showed much promise and need further study.

Effect of Post-transplant Applications of

Granular Herbicides on Marigold

C. Haramaki and S. Atmore¹

In 1961, a number of pre-transplant herbicides were tested for weed control and also for their effect on the growth of the Spry Marigold. Several of the chemicals gave adequate weed control with little or no injury to the transplants when incorporated in the soil. Difficulty was expressed by some growers in treating the soil prior to planting. This experiment was set up to study the effectiveness of post-transplant applications of granular herbicides on weed control and plant injury.

Methods and Materials

The Hagerstown silt loam was disced and meekered several times prior to planting. On July 1, 1963 all of the plants were transplanted and one half inch of water was applied after planting. The test plant used was Spry, a dwarf double French marigold. Ten herbicides at three concentrations plus a check were replicated three times in a split, split plot design. The granular herbicides were applied 3, 7, 9, 11, and 17 days after planting. There were eight plants in each of the 600 sub, sub plots. The chemicals used were:

amiben, 10G (Amchem)
 CIPC, 5G (Pittsburgh Plate Glass)
 dichlobenil, 4G (Thompson-Hayward)
 diuron, 2G (Miller)
 EPTC, 10G (Stauffer)
 R-1607, 10G (Stauffer)
 R-4572, 10G (Stauffer)
 SD-7961, 5G (Shell)
 simazine, 4G (Geigy)
 swep, 5G (Niagara)

Results and Discussion

On August 6 and September 4, 1963, which was approximately five and nine weeks after planting, the plots were checked for weed control. The data are summarized in Table 1. Since the dates of application varied from 3 days to 17 days after planting, the time between herbicide application and the date of checking under the 5 week columns varied from 33 days for the 3 days after planting column to 19 days for the 17 days after planting column.

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Table 1. Effect of Post-Transplant Herbicides on Weed Prevalence, Five and Nine Weeks After Planting, 1963.

Herbicide	Time of Treatment After Transplanting										AVE.	
	3 days		7 days		9 days		11 days		17 days			
	5 w	9 w	5 w	9 w	5 w	9 w	5 w	9 w	5 w	9 w	5 w	9 w
Amiben												
0	4.0	8.3	4.0	9.0	3.7	9.3	3.0	7.3	1.0	4.0	3.1	7.6
2½ #/A	1.0	3.3	2.0	4.3	2.3	4.3	1.3	3.0	1.0	1.3	1.5	3.3
5 #/A	1.0	2.3	1.7	4.3	2.0	4.0	1.0	2.3	0.3	1.0	1.2	2.8
10 #/A	0.3	1.3	1.0	1.7	1.0	1.7	0.7	1.7	1.0	1.0	0.8	1.5
CIPC												
0	4.3	9.7	4.7	10.0	4.0	9.0	3.0	8.3	1.3	6.0	3.5	8.6
2½ #/A	2.3	3.7	2.3	3.3	2.0	2.7	1.3	3.3	0.3	1.3	1.7	2.9
5 #/A	1.3	3.7	1.3	3.3	1.7	3.3	1.7	2.7	0.7	2.0	1.3	3.0
10 #/A	0.0	1.3	0.0	1.0	0.3	1.0	0.0	0.7	0.7	1.7	0.2	1.1
Dichlobenil												
0	4.0	9.3	3.7	9.3	3.3	9.0	3.7	7.7	1.3	5.3	3.2	8.1
1 #/A	3.3	7.7	3.3	7.7	2.7	8.0	2.7	6.7	1.3	3.7	2.7	6.7
2 #/A	2.7	6.7	3.0	7.0	2.3	5.3	2.7	4.3	0.7	3.0	2.3	5.3
4 #/A	1.3	4.3	2.0	5.0	1.3	3.7	0.7	2.0	0.7	1.7	1.2	3.3
Diuron												
0	4.0	9.0	4.3	10.0	4.3	10.0	3.3	10.0	2.0	6.7	3.6	9.1
1 #/A	0.7	2.0	0.3	1.0	0.7	1.7	0.7	2.0	0.0	1.3	0.5	1.6
2 #/A	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1
4 #/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EPTC												
0	3.7	7.7	3.3	8.0	3.3	7.3	2.7	6.3	2.0	4.3	3.0	6.7
2½ #/A	2.3	5.3	2.0	4.7	1.7	4.0	1.3	3.0	0.7	1.3	1.6	3.7
5 #/A	1.3	4.0	1.3	4.0	1.0	3.3	0.7	2.0	0.3	1.0	0.9	2.9
10 #/A	1.3	3.0	0.7	2.7	0.7	2.7	0.7	1.3	0.3	0.7	0.7	2.1
R-1607												
0	3.7	8.3	3.3	8.3	3.3	8.0	3.0	8.0	1.7	6.0	3.0	7.7
2½ #/A	3.0	7.3	2.3	6.0	1.7	4.3	1.0	2.7	0.7	1.7	1.7	4.4
5 #/A	2.0	5.3	1.0	3.7	0.7	3.3	0.7	2.3	0.0	1.0	0.9	3.1
10 #/A	1.7	4.3	0.3	2.0	0.3	1.7	0.0	1.0	0.0	1.0	0.4	2.0
R-4572												
0	4.0	9.3	3.7	9.7	3.7	9.0	3.3	7.7	2.3	6.7	3.4	8.5
2½ #/A	4.7	7.3	4.0	7.3	3.7	5.3	1.7	4.3	0.3	2.0	2.9	5.3
5 #/A	2.7	4.7	1.7	5.0	2.3	4.3	1.3	3.0	0.7	2.7	1.7	3.9
10 #/A	1.0	2.3	0.3	1.0	0.7	2.0	0.3	1.0	0.3	0.7	0.5	1.4
SD-7961												
0	4.7	9.0	4.3	9.7	4.0	7.3	4.0	7.7	1.3	4.7	3.7	7.7
1 #/A	2.7	7.7	2.3	7.7	3.0	8.0	2.0	6.7	1.0	5.0	2.2	7.0
2 #/A	3.3	8.0	2.3	6.7	2.7	6.0	2.3	5.7	1.3	4.7	2.4	6.2
4 #/A	2.0	3.7	1.3	4.3	2.7	4.3	2.7	2.0	0.3	1.7	1.8	3.2

Table 1. (Continued) Effect of Post-Transplant Herbicides on Weed Prevalence, Five and Nine Weeks After Planting, 1963.

Herbicide	Time of Treatment After Transplanting										AVE.	
	3 days		7 days		9 days		11 days		17 days			
	5 w	9 w	5 w	9 w	5 w	9 w	5 w	9 w	5 w	9 w	5 w	9 w
Simazine												
0	4.0	9.7	4.0	9.7	4.0	9.7	3.0	8.3	1.0	4.7	3.2	8.4
1 #/A	3.0	7.3	2.3	5.7	2.3	5.3	2.7	5.0	1.3	5.0	2.3	5.7
2 #/A	1.7	4.0	0.7	2.0	1.0	2.3	0.7	2.3	1.0	3.3	1.0	2.8
4 #/A	1.0	4.0	0.0	0.3	0.0	0.7	0.0	0.3	0.3	2.7	0.3	1.5
SWEP												
0	4.0	9.3	3.7	9.7	3.3	10.0	3.3	8.3	1.3	4.3	3.1	8.3
2 #/A	1.7	4.0	2.0	4.3	1.7	4.0	1.7	3.0	0.3	1.7	1.5	3.4
4 #/A	1.0	2.3	1.3	2.7	1.3	2.3	1.0	2.0	0.3	2.3	1.0	2.3
8 #/A	0.3	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.3	0.7	0.1	0.4

Weed Prevalence

- 0 - No Weeds
- 10 - 100% Weed Coverage

Good weed control was observed five weeks after planting in plots treated with amiben at 2 1/2, 5, and 10 pounds per acre; CIPC at 2 1/2, 5, and 10 pounds per acre; dichlobenil at 4 pounds per acre; diuron at 1, 2 and 4 pounds per acre; EPTC at 2 1/2, 5, and 10 pounds per acre; R-1607 at 2 1/2, 5, and 10 pounds per acre; R-4572 at 5, and 10 pounds per acre; SD-7961 at 4 pounds per acre; simazine at 2 and 4 pounds per acre; and swep at 2, 4 and 8 pounds per acre. Nine weeks after planting, good weed control was observed in plots treated with amiben, CIPC, and R-4572 at 10 pounds per acre; diuron at 1, 2 and 4 pounds per acre; simazine at 4 pounds per acre; and swep at 8 pounds per acre. The high summer temperatures undoubtedly reduced the effectiveness of a number of the more volatile chemicals.

The principal weeds were yellow foxtail, tumble pigweed, Canada thistle, fall panicum, field peppergrass, Pennsylvania smartweed, and common ragweed. Less frequent weeds included redroot pigweed, shepardspurge, wild carrot, buckhorn plantain, milkweed, ground cherry, tomato, purslane, blackseed plantain, oxalis, yellow rocket, barnyard grass, alsike clover, red clover, giant foxtail, and prostrate spurge.

On September 6, 1963 the marigold plants were examined for injury and also their height was measured. The data on plant injury are summarized in Table 2. Plant injury such as discoloration, necrosis, and death was slight in almost all of the treatments. Where some injury was noted, in general its severity increased as the herbicide concentration increased and when the time between herbicide application and planting decreased. This was noticed in plots treated with dichlobenil, diuron, and SD-7961.

Table 2. Effect of Post-Transplant Applications on Marigold, Checked Nine Weeks After Planting, 1963.

Herbicide	Active Rate	Time of Treatment After Transplanting					AVE.
		3 days	7 days	9 days	11 days	17 days	
Amiben	0	0.29	0.42	0.13	0.33	0.17	0.27
	2½ #/A	0.33	0.67	0.50	0.25	0.25	0.40
	5 #/A	0.29	0.29	0.25	0.33	0.17	0.27
	10 #/A	0.33	0.38	0.33	0.29	0.13	0.29
CIPC	0	0.54	0.13	0.58	0.17	0.75	0.43
	2½ #/A	0.38	0.13	0.21	0.17	0.08	0.19
	5 #/A	0.42	0.21	0.42	0.04	0.54	0.37
	10 #/A	0.04	0.75	0.13	0.21	0.25	0.28
Dichlobenil	0	0.25	0.75	0.38	0.33	0.63	0.46
	1 #/A	0.42	0.63	0.38	0.21	0.17	0.37
	2 #/A	1.88	0.67	0.71	0.29	0.21	0.75
	4 #/A	1.58	0.54	0.46	0.46	0.42	0.83
Diuron	0	0.17	0.13	0.46	0.29	0.16	0.24
	1 #/A	0.29	0.17	0.42	0.08	0.29	0.25
	2 #/A	0.50	0.13	0.75	0.42	0.13	0.38
	4 #/A	1.13	0.42	0.46	0.63	0.79	0.78
EPTC	0	0.38	0.54	0.21	0.33	0.42	0.38
	2½ #/A	0.50	0.08	0.08	0.33	0.63	0.33
	5 #/A	0.42	0.21	0.38	0.33	0.67	0.40
	10 #/A	0.29	0.54	0.17	0.63	0.46	0.42
R-1607	0	0.25	0.38	0.08	0.17	0.21	0.23
	2½ #/A	0.46	0.25	0.63	0.42	0.42	0.43
	5 #/A	0.17	0.04	0.21	0.25	0.42	0.22
	10 #/A	0.33	0.33	0.88	0.50	0.46	0.50
R-4572	0	0.25	0.25	0.54	0.17	0.25	0.29
	2½ #/A	0.42	0.17	0.38	0.46	0.25	0.33
	5 #/A	0.25	0.46	0.13	0.17	0.17	0.25
	10 #/A	0.54	0.46	0.50	0.38	0.04	0.37
SD-7961	0	0.29	0.54	0.33	0.25	0.17	0.32
	1 #/A	0.25	0.29	0.21	0.29	0.29	0.27
	2 #/A	0.29	0.29	0.46	0.67	0.46	0.43
	4 #/A	1.38	1.25	0.46	1.17	0.96	1.04
Simazine	0	0.08	0.33	0.38	0.29	0.25	0.27
	1 #/A	0.17	0.46	0.63	0.17	0.08	0.30
	2 #/A	0.25	0.25	0.33	0.25	0.29	0.28
	4 #/A	0.08	0.83	0.25	0.33	0.29	0.36
Swep	0	0.33	0.25	0.33	0.33	0.25	0.30
	2 #/A	0.21	0.33	0.46	0.25	0.29	0.33
	4 #/A	0.21	0.29	0.46	0.25	0.33	0.31
	8 #/A	0.29	0.33	0.17	0.38	0.17	0.27

Plant Injury: 0 = No Injury

Table 3. Height of Marigold Plants in Inches, Nine Weeks After Planting, 1963.

Herbicide	Active Rate	Time of Treatment After Transplanting					AVE.
		3 days	7 days	9 days	11 days	17 days	
Amiben	0	11.96	12.25	11.50	11.46	11.96	11.83
	2½ #/A	11.63	11.04	11.50	11.63	11.71	11.50
	5 #/A	11.25	11.54	11.29	11.96	11.38	11.48
	10 #/A	11.92	11.92	12.33	11.63	12.08	11.98
CIPC	0	12.38	12.04	11.79	11.25	12.33	11.96
	2½ #/A	11.67	11.17	11.21	11.25	11.75	11.41
	5 #/A	11.63	11.54	11.67	11.29	11.63	11.55
	10 #/A	11.54	11.79	11.50	11.33	11.83	11.56
Dichlobenil	0	11.46	12.50	12.38	11.50	11.58	11.88
	1 #/A	12.46	11.50	12.38	12.20	12.58	12.14
	2 #/A	9.33	12.00	13.33	12.63	12.92	12.04
	4 #/A	8.21	11.46	12.00	11.83	12.00	11.10
Diuron	0	11.83	11.63	11.88	12.20	12.38	11.98
	1 #/A	11.75	12.04	11.71	11.63	11.88	11.80
	2 #/A	10.25	11.79	11.00	11.88	11.54	11.29
	4 #/A	9.41	10.63	9.17	10.00	9.67	9.77
EPTC	0	12.33	11.88	12.08	12.08	12.33	11.98
	2½ #/A	12.04	12.13	12.04	11.92	12.42	12.11
	5 #/A	11.59	12.20	11.83	11.58	12.25	11.89
	10 #/A	12.04	12.29	12.25	11.67	12.75	12.25
R-1607	0	11.63	12.25	11.79	11.29	11.42	11.68
	2½ #/A	11.46	12.04	12.17	12.42	11.42	11.90
	5 #/A	12.13	12.54	11.71	12.38	12.13	12.18
	10 #/A	11.25	11.08	11.79	11.79	12.38	11.66
R-4572	0	12.21	11.75	11.25	11.92	12.17	11.86
	2½ #/A	12.17	11.79	11.50	11.83	12.54	11.98
	5 #/A	11.71	11.21	11.08	11.04	12.88	11.58
	10 #/A	12.88	12.20	11.96	12.00	12.04	12.22
SD-7961	0	11.83	11.42	11.08	11.58	11.79	11.54
	1 #/A	12.38	11.96	11.42	11.04	12.17	11.79
	2 #/A	12.00	11.58	11.33	11.21	12.17	11.66
	4 #/A	10.63	10.63	11.46	11.63	10.71	11.01
Simazine	0	12.38	12.00	12.04	11.71	11.75	11.97
	1 #/A	11.13	11.33	11.33	11.92	12.54	11.65
	2 #/A	11.96	11.54	11.00	11.29	11.17	11.39
	4 #/A	11.21	11.04	11.42	11.25	12.25	11.43
Swep	0	11.38	11.63	10.75	11.25	12.04	11.40
	2 #/A	11.88	12.04	10.88	12.17	12.08	11.85
	4 #/A	12.04	11.63	11.50	12.42	11.62	11.84
	8 #/A	12.25	12.38	10.88	10.96	12.13	11.88

The height of the marigold plants nine weeks after planting is summarized in Table 3. In general there was little variation in height between the treatments. Some reduction in height was noticed in plots treated with the higher concentrations of dichlobenil, diuron and SD-7961 shortly after planting.

Summary

Ten different granular herbicides at three concentrations were applied to transplanted Spry marigolds 3, 7, 9, 11, and 17 days after planting. All of the herbicides gave good weed control for at least five weeks at one or more rates of application used. Nine weeks after planting good weed control was noticed in plots treated with six of the herbicides at one or more rates of application used.

The post-transplant applications of granular herbicides caused little plant injury and little reduction in height. Where plant injury and reduction in height was noticed, it was intensified as the concentration increased and the time between planting and herbicide application was reduced.

1963 Trials with Herbicides in Nursery Plantings

John F. Ahrens^{1/}

The per acre cost of controlling weeds probably is higher for nursery plantings than for any other crop. Yet there are many nursery plant situations for which little information on safe herbicides is available. Two of these plant situations are field-grown azaleas and bed-grown stock.

Previous experiments had shown that simazine at 2 lbs. per acre and chloro IPC at 6 lbs. per acre sometimes injured 2-year bed-grown hemlock transplants, and observations among growers indicated that azaleas were often injured by simazine. While Taxus spp. generally are considered to be among the most tolerant of woody nursery stock to herbicides, the capitata variety of Taxus cuspidata is an exception. The following experiments were conducted during the 1963 season to evaluate newer herbicides for use in bed-grown capitata yews and hemlocks, and field-grown azaleas.

Procedure and Results

Herbicides were applied as sprays or in granular form, using a calibrated knapsack sprayer, a precision augur-feed granular applicator, or by diluting granules with sand and spreading over plot areas. The following herbicides and formulations were used in these tests:

- a) diphenamid /N,N-dimethyl-2,2-diphenylacetamide/, 80% w.p.
- b) DCPA /dimethyl-2,3,5,6-tetrachloroterephthalate/, 75% w.p.
- c) simazine /2-chloro-4,6-bis(ethylamino)-s-triazine/, 80% w.p.
- d) CIPC /isopropyl N-(3-chlorophenyl)carbamate/, 20% gr.
- e) trifluralin /a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine/, e.c.
- f) dichlobenil /2,6 dichlorobenzonitrile/, 50% w.p.

Field-grown azaleas

A block of Azalea poukhanense (2-year transplants) was lined out on June 15, 1962 in a commercial nursery, located on a fine sandy loam soil, very high in organic matter. Plots consisted of a single row, 12 plants long. The treatments were replicated three times in a completely randomized block design with two untreated plots per replicate.

The herbicide treatments shown in Table 1 were applied on July 8, after hoeing the moist soil to remove existing weeds. The treatments were applied in a three-foot band directly over the rows. The rows were cultivated about every two weeks as in normal commercial practices.

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Weed counts were made on July 30 and the comparisons of the treatments with the control plots are shown in Table 1. Weeds were rather sparse in this test with control plots averaging only 20 weeds on July 30. The main weeds were purslane, lambsquarters, and a small amount of crabgrass. All treatments greatly reduced the number and size of the weeds but some large purslane plants were found in every plot, indicating that they had been missed or covered in the initial hoeing. Following hoeing of the plots on July 20, weed control again was observed on September 16. At that time weed populations again were small and variable but comparisons were made between treatments and the weedier check in each replicate. Because of the variability in weed populations, the differences between treatments shown in Table 1 probably are not significant. However, control of purslane and lambsquarters was uniformly good with diphenamid, CIPC, and diphenamid plus trifluralin or simazine.

Injury evaluations were made in July, September and October. Injury ratings for September and October were similar and are averaged in Table 1. The average number of dead and severely injured plants per plot in October is also shown in Table 1. The data show that all treatments, including the control, apparently injured the azaleas. It was later found that the injury in control plots was due largely to excessive nutrient levels in the soil. Most of the herbicide injury occurred in one replicate where the plants were affected most by abnormal soil conditions. Thus, the herbicides added to the injury of already weakened plants and had little effect on healthy plants. However, the higher rates of DCPA, trifluralin, and CIPC also injured plants in the healthy group but to a lesser degree.

Bed-grown taxus and hemlocks

Two-year seedlings of *Taxus cuspidata capitata* and *Tsuga canadensis* were planted by machine into ground beds between May 20 and May 30, 1963. The planting was part of a commercial nursery operation in Windsor, Connecticut, on a fine sandy loam soil. Plot sizes were five feet by four feet (the width of the beds) in the taxus and four feet by four feet in the hemlocks. Border strips two feet wide separated the plots. The taxus plots contained about 135 plants and the hemlock plots contained about 85 plants.

The treatments were replicated three times in the taxus bed and twice in the hemlock bed, in randomized complete block design. Two untreated plots were included per replicate. The treatments were applied on July 10, 1963 after removing any existing weeds and dead plants and lightly scratching the moist soil.

Despite a dry August, the soil in this test was kept moist by periodic irrigation. The hemlock bed also was shaded with lath, as in normal nursery practice.

The herbicide treatments and their effects on weeds and the nursery plants are shown in Table 2. On August 19, it was judged that 87 per cent of the area in the untreated plots was occupied by weeds, consisting mainly

of purslane, crabgrass, stinkgrass, lambsquarters and pigweed. Diphenamid and dichlobenil at 4 lbs. per acre did not control purslane as well as the other treatments possibly because some small purslane seedlings had been missed in the initial weeding. In previous tests diphenamid has controlled purslane to a high degree.

Plots treated with the combination of diphenamid at 4 lbs. per acre plus simazine at 1 lb. per acre were completely free of weeds. However, every herbicide provided acceptable weed control in this test and would have resulted in great reductions in time required to weed the beds. Following removal of the weeds late in August, few new weeds grew in any of the plots.

Measurements were made in September of the terminal shoots on each of 20 plants taken at random from the center of the plots. Counts of the total numbers of plants and the number dead in each plot also were made and the results are shown in Table 2.

Dichlobenil caused severe necrosis on hemlocks and discoloration on taxus in August and consequently affected growth and mortality in both species. However, on taxus, dichlobenil at 4 lbs. per acre did not seem to cause visible injury or reduce the growth but did increase mortality. The effect on hemlocks was noticeable at both rates of dichlobenil. Although no other injury symptoms were detected, the data in Table 2 indicate that trifluralin at 3 lbs. per acre may have injured taxus but not hemlocks. CIPC also may have caused slight increases in the mortality of taxus and hemlocks.

DCPA, diphenamid and a low rate of simazine alone or in combination did not appear to have affected the hemlocks or taxus transplants in this test.

Summary

Several herbicides were evaluated in liners of Azalea poukhanense and bed-grown Taxus cuspidata and Tsuga canadensis. In azaleas, every herbicide tested caused injury under adverse soil conditions. However, those treatments causing little or no injury to healthy plants included diphenamid w.p. at 4 or 8 lbs. per acre, granular CIPC at 8 lbs. per acre, DCPA w.p. at 8 lbs. per acre, trifluralin e.c. at 2 lbs. per acre, diphenamid w.p. at 2 lbs. per acre plus trifluralin e.c. at 2 lbs. per acre, and diphenamid w.p. at 4 lbs. per acre plus simazine w.p. at 1 lb. per acre.

In bed-grown Taxus cuspidata capitata and Tsuga canadensis, apparently safe treatments included diphenamid w.p. at 4 or 8 lbs. per acre, DCPA w.p. at 8 or 12 lbs. per acre, trifluralin e.c. at 2 lbs. per acre, diphenamid w.p. at 4 lbs. per acre plus simazine w.p. at 1 lb. per acre and simazine w.p. alone at 1.5 lbs. per acre. Dichlobenil w.p. at 4 or 6 lbs. per acre injured both the taxus and hemlock transplants.

Table 1. Control of Weeds in Azaleas

Herbicide	Rate a.i. lbs./A	Percentage control of weeds		Injury ratings ^{1/}	No. of dead and injured plants ^{2/}
		7/30	9/12		
weedy checks		0	14	.3	.2
diphenamid, w.p.	4 8	74 90	98 93	1.0 1.2	1.7 1.7
CIPC, gr.	8 16	78 70	90 96	.7 1.0	1.0 1.3
DCPA, w.p.	8 12	80 95	75 87	.8 1.8	.7 2.7
trifluralin, e.c.	2 3	58 75	73 78	.5 1.1	.7 2.0
diphenamid, w.p. + trifluralin, e.c.	2 2	85	97	.8	.3
diphenamid, w.p. + simazine, w.p.	4 1	83	92	.8	1.3

^{1/} 0=no injury, 5=dead plants, average ratings for September and October.

^{2/} Average number of dead plus severely injured plants per plot in October.

Table 2. Control of Weeds in Beds of Taxus and Hemlocks.

Herbicide	Rate a.i. lbs./A	Percentage control of weeds 8/19 ^{1/}	Taxus		Hemlocks	
			Growth in cm. ^{2/}	Mortal- ity ^{3/}	Growth in cm. ^{2/}	Mortal- ity ^{3/}
weedy control		0	70	1.0	407	0
diphenamid,w.p.	4 8	74 85	51 69	1.2 1.3	395 388	0.5 0
CIPC, gr.	6 8	87 93	-- 64	- 3.0	379 -	1.9 -
DGPA, w.p.	8 12	97 91	67 79	1.5 2.0	382 409	0 0
trifluralin,e.c.	2 3	93 99	62 47	0.9 3.1	421 419	0 0
diphenamid,w.p.+ simazine,w.p.	4 1	100	72	2.3	390	0
simazine,w.p.	1.5	97	84	0.9	371	0
dichlobenil,w.p.	4 6	79 92	79 57	3.3 2.0	358 289	5.5 23.4
L.S.D. p=.05			20		66	

^{1/}Based on ratings of area covered by weeds.

^{2/}Total new growth of terminal shoots on 20 plants 9/23/63.

^{3/}Percentage dead plants on 9/23/63.

Chemical Weed Control in Selected Pennsylvania Nurseries

C. S. Oliver¹ and Chiko Haramaki²

Introduction

In recent years many nurserymen have noticeably reduced labor and operating costs by the use of selective herbicides. However, the indiscriminant use of herbicides on nursery stock has also added many new problems to the production of ornamental plants.

The interest and use of herbicides for selective weed control has created a most unique situation new to the nurseryman. As a result, the problem no longer is what herbicide will control a specific weed, but that of many complex problems which have evolved concerning residual effects, time and methods of application for most effective control, and plant tolerance to chemicals. These problems can only be answered by continuous testing, evaluation and field demonstration of herbicide materials.

In the tests described several herbicide materials were applied to selected narrowleaf evergreen species in the fall of the year.

Objectives

1. To determine, through the use of selected herbicides, the length of time effective weed control could be maintained on varying soil types.
2. To determine the tolerance of plants growing on varying soil types to selected herbicides.

Materials and Methods

For the purpose of this study ten nurseries throughout the Commonwealth were selected as test areas for making field observations of selected herbicides. The herbicide materials were applied at each nursery during the month of October, 1962.

All plant materials selected for use in the study were narrowleaf evergreen species which had been growing in the nursery row a minimum of six weeks before herbicide applications were applied. The soil area between and in the row of the test plots were clean cultivated just prior to applying herbicide materials. Each treatment plot measured approximately one-hundredth of an acre and the plots were arranged in randomized blocks.

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Herbicide materials had never been previously applied to these treatment areas.

Table 1 indicates the plant materials, soil type and soil condition of the time of applying herbicides to each plot location.

The following herbicides were compared in this test:

- a. Simazine - 80% wettable powder
- b. Simazine - 4% granular
- c. Atrazine - 80% wettable powder
- d. Atrazine - 8% granular
- e. Amizine - 60% wettable powder
- f. Diuron - 2% granular
- g. EPTC - 10% granular

The wettable powder materials were mixed with 2 gallons of water and applied with a constant pressure knapsack sprayer. The spray was applied to the plot area without regard to the plant foliage. The granular materials were applied by hand spreading, since the quantities applied were too small for accurate use of mechanical applicators.

Results and Discussion

The plots were examined during June and again in August, 1963 for weed control which is summarized in Table 2. Effective control of annual weeds was apparent in all plots where atrazine, simazine and amizine were used. There also appeared to be little visual difference between liquid and granular triazine materials in controlling weeds. Diuron produced erratic weed control results on the plots where tested but, in general, moderate weed control was achieved. EPTC plots were quite unsatisfactory in the weed control received but they appeared somewhat superior to the check plots. The poor control in EPTC plots was attributed to not incorporating the material into the soil surface after applying.

Table 3 shows the effects of herbicides on weed prevalence eight months after treatment. It should be noted that in the atrazine, amizine and simazine plots the predominant weeds were perennial weeds such as quackgrass, Canada thistle, dandelion and field bindweed. These weeds were usually found in the row which was an indication that poor cultivation occurred before herbicides were applied.

The plots when checked in August showed a small increase in weed prevalence as is indicated in Table 2. However, the weed species present had maintained a similar order of frequency as appears in Table 3.

No damage was apparent on any of the plant materials where herbicides were applied. The varying soil type and soil condition also appeared to have little effect upon the herbicide materials' ability to give effective weed control. EPTC and diuron, however, did have a tendency to show erratic control when used on varying soil conditions.

Table 1. PLANT MATERIALS, SOIL TYPE AND SOIL CONDITION AT TIME
OF APPLYING HERBICIDES AT SELECTED NURSERY LOCATIONS

Nursery Number	Plants	Size	Soil Type	Soil Condition
1	<u>Taxus hunewelliana</u> <u>Taxus thayeri</u>	Liners 9"-12"	Morris Sandy Loam	Wet and poorly drained.
2	<u>Taxus media mooni columnaris</u>	9"-12"	Allentown Silt-Clay Loam	Fair soil moisture.
3	<u>Taxus media densiformis</u> <u>Tsuga canadensis</u> <u>Picea abies</u>	15"-18" 12"-15" 3'-4'	Duffield Silt-Clay Loam	Excellent soil moisture.
4	<u>Thuja occidentalis wareana</u> <u>Chamaecyparis juniperoides</u> <u>Taxus intermedia</u>	9"-12" 9"-12" 18"-24"	Wiltshire Silt-Clay	Excellent soil moisture.
5	<u>Taxus media hicksi</u>	2'-2½'	Gilpin Silt-Clay Loam	Rained during application.
6	<u>Tsuga canadensis</u>	18"-24"	Brooke Silt-Clay Loam	Good soil moisture.
7	<u>Thuja occidentalis wareana</u> <u>Thuja occidentalis pyramidalis</u>	18"-24"	Holston Silt-Clay Loam	Good soil moisture.
8	<u>Juniperus glauca hetzi</u>	12"-15"	Ernest Silt-Clay Loam	Good soil moisture.
9	<u>Taxus cuspidata pyramidalis</u>	2½'-3'	Venango Silt-Clay Loam	Wet and poorly drained.
10	<u>Thuja occidentalis pyramidalis</u>	3'-4'	Langford Silt Loam	Good soil moisture.

Table 2. EFFECT OF FALL HERBICIDE APPLICATIONS ON WEED CONTROL IN SELECTED NARROWLEAF EVERGREENS
Checked Eight Months (June) and Ten Months (August) After Treatment

Herbicide and Formulation	Rate of Application	Weed Control Rating ^{1/}												Average ^{1/} Weed Rating			
		1		2		3		4		5		6		7		^{2/}	^{3/}
		^{2/}	^{3/}														
Atrazine 80% W.P.	3	0	0	.5	5	2	3	0	0	.5	2	0	0	0	1	0.4	1.6
Atrazine 8% G	3	0	0	.5	3	2	3	0	0	1	5	.5	2	.5	1	0.6	2.0
Amizine 60% W.P.	4	0	0	.5	7	3	5	.5	.5	.5	1	0	0	.5	1	0.7	2.1
Simazine 80% W.P.	3	0	0	.5	1	2	2	.5	.5	.5	.5	.5	1	2	2	0.9	1.0
Simazine 4% G	3	0	0	.5	1	2	2	2	2	.5	.5	.5	1	2	2	1.1	1.2
Diuron 2% G	2	0	1	7	7	7	8	2	5	4	8	1	2	.5	9	3.1	5.7
EPTC 10% G	6	2	4	10	10	6	9	5	6	9	10	9	10	9	9	7.1	8.3
Check		7	7	10	10	9	10	10	10	10	10	9	10	10	10	9.3	9.6

^{1/} Weed Prevalence Scale: 1 = 10% or less weed coverage
10 = 100% weed coverage

^{2/} Weed ratings taken June, 1963

^{3/} Weed ratings taken August, 1963

Table 3. EFFECT OF HERBICIDES ON WEED PREVALENCE EIGHT MONTHS AFTER TREATMENT
(Treated October, 1962 - Checked June, 1963)

Herbicide	Average weed prevalence at all test sites <u>1/</u>	Weeds present in a decreasing order of frequency
Atrazine 80 W 3 lbs./A.	0.4	Quackgrass, dandelion, field bindweed, common ragweed, black medic.
Atrazine 8% G 3 lbs./A.	0.6	Quackgrass, dandelion, Canada thistle, wild carrot, shepherds purse, mayweed, henbit.
Amizine 60 W 4 lbs./A.	0.7	Quackgrass, dandelion, field bindweed, annual bluegrass, Canada thistle, common chickweed, red sorrel.
Simazine 80 W 3 lbs./A.	0.9	Quackgrass, dandelion, Canada thistle, field bindweed, common ragweed, red sorrel.
Simazine 4% G 3 lbs./A.	1.1	Quackgrass, dandelion, Canada thistle, field bindweed, field peppergrass, yellow rocket, red sorrel.
Diuron 2% G 2 lbs./A.	3.1	Field peppergrass, Pennsylvania smartweed, common ragweed, broadleaf plantain, dandelion, annual fleabane, shepherds purse, henbit, red sorrel, quackgrass, field bindweed, timothy, Canada thistle, mayweed, common purslane.
EPTC 10% G 6 lbs./A.	7.1	Field peppergrass, common chickweed, broadleaf plantain, quackgrass, dandelion, red clover, yellow rocket, Canada thistle, annual fleabane, timothy, prostrate knotweed, henbit, shepherds purse, mayweed, red sorrel, common ragweed, slender rush.
Check	9.3	Common chickweed, quackgrass, field peppergrass, dandelion, annual bluegrass, wild carrot, red sorrel, Canada thistle, common ragweed, broadleaf plantain, field bindweed, red clover, Pa. smartweed.

1/ Weed Prevalence Scale - 1 - 10% or less weed coverage
10 - 100% weed coverage

It should be noted that three of the nurseries selected to participate in this study are not included in the data collected and illustrated in either Table 2 or 3. Uncontrollable conditions occurred which did not permit the accurate recording of data so the results were not recorded.

Summary

1. Fall applications of atrazine - 3 lbs./A., simazine - 3 lbs./A. and amazine - 4 lbs./A. gave effective spring and summer weed control when used on selected narrowleaf evergreen species. Little or no plant injury was observed on any of the plant species tested in any of the treatments.
2. Fall applications of atrazine - 3 lbs./A., simazine - 3 lbs./A. and amazine - 4 lbs./A. gave effective weed control when used on many different soil types.
3. There is little difference in the ability of simazine or atrazine to provide good weed control when applied as a spray or granular material.

Pre-transplant Weed Control in Liner Beds

Chiko Haramaki¹

During the past few years we have found that a number of different herbacious ornamental plant species can be successfully transplanted in soil which had been previously treated with pre-transplant herbicides. Many nurseries transplant their rooted cuttings of woody plants or liners in beds at close spacing, which makes it difficult to use mechanical cultivation. The objectives in this experiment were to obtain satisfactory weed control with the use of pre-transplant herbicides and to determine the extent of injury on narrow- and broadleaf-evergreen rooted cuttings which were transplanted in the treated beds.

Methods and Materials

The area used in the test was covered by a heavy growth of quackgrass, which was approximately 2-3 feet in height. The soil was plowed, disced and rototilled just prior to treatment. On August 16, 1963 the plots were treated with the following chemicals:

Dichlobenil, 50 WP (Thompson-Hayward)
EPTC, 6 e.c. (Stauffer)
R-1607, 6 e.c. (Stauffer)
SD-7961, 50 WP (Shell)
Sun 60 Wax (Sunoco)
Trifluralin, 4 e.c. (Eli Lilly).

After each herbicide was applied to the soil it was immediately rototilled to a depth of 2-3 inches. Sun 60 wax was used in one treatment as a sealant for the incorporated EPTC. Two quarts of emulsifiable wax was mixed with eight quarts of water and the emulsion sprayed on 1000 square feet.

Eleven days later on August 27, 1963 the beds were lightly rototilled to break the crust and the rooted cuttings were planted. There were ten different narrow-leaf evergreen varieties and ten different broadleaf evergreen varieties. An average of 226 plants of each variety was used. One inch of water was applied after transplanting.

Results and Discussion

On September 26, 1963, which was six weeks after treatment, the plots were examined for weed prevalence. This is summarized in Table 1. Good weed control was obtained with SD-7961 and dichlobenil at 3 pounds per acre and satisfactory weed control was obtained with EPTC, EPTC plus Sun 60 wax,

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Table 1. Effect of Pre-Transplant Herbicides on Weed Prevalence, Six Weeks After Treatment, 1963.

Herbicide	Weed Prevalence	Weeds Present in Decreasing Frequency
Check	10.0	Quackgrass, wild mustard, canada thistle, common lambs-quarter, dandelion, white cockle
SD-7961 3 #/A	0.8	Quackgrass
Dichlobenil 3 #/A	1.0	Quackgrass wild mustard
EPTC 10 #/A	1.8	wild mustard dandelion, canada thistle
EPTC 10 #/A + Sun 60 Wax	1.8	wild mustard canada thistle quackgrass
R-1607 10 #/A	1.8	wild mustard canada thistle, quackgrass broadleaf dock, dandelion
Trifluralin 2 #/A	5.0	Quackgrass canada thistle

Weed Prevalence

0 = No Weeds

10 = 100% Weed Coverage

Table 2. Effect of Pre-Transplant Herbicide on Narrow and Broad Leaved Evergreens, Which Were Transplanted 11 Days after Treatment, 1963.

Species	EPTC	Dichlo- benil	R-1607	EPTC + Wax	SD-7961	Tri- flura- lin	Check
Narrow Leaf							
<u>Chamaecyparis obtusa</u>	0.18	0.17	0.03	0.10	0.10	0.16	0.00
<u>C. pisifera filifera</u>	1.75	0.50	1.25	1.00	0.25	0.50	1.25
<u>C. P. plumosa</u>	0.07	0.09	0.06	0.05	0.08	0.03	0.11
<u>C. P. squarrosa</u>	1.13	0.88	1.13	2.38	1.75	2.13	0.75
<u>Juniperus chinensis</u>							
<u> glauca hetzi</u>	0.00	0.00	0.00	0.05	0.00	0.05	0.00
<u>J. horizontalis plumosa</u>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<u>J. sabina</u>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<u>J. squarrosa meyeri</u>	0.00	0.42	0.00	0.00	0.00	0.00	0.00
<u>Taxus cuspidata</u>	0.22	0.31	0.28	1.00	0.74	0.38	0.42
<u>T. C. nana</u>	0.06	0.20	0.11	0.04	0.04	0.10	0.12
Broad Leaf							
<u>Berberis julianae</u>	0.60	0.58	0.90	0.65	0.80	0.79	0.47
<u>Buxus sempervirens</u>	0.35	0.07	0.14	0.05	0.10	0.29	0.29
<u>Euonymus fortunei</u>	1.60	1.00	1.14	1.11	1.02	1.00	1.07
<u>Ilex crenata</u>	0.06	0.14	0.15	0.08	0.03	0.05	0.00
<u>I. C. 'Green Island'</u>	0.71	0.00	0.33	0.09	0.00	0.00	0.00
<u>I. glabra</u>	0.06	0.06	0.06	0.13	0.36	0.00	0.27
<u>Leucothoe catesbaei</u>	1.52	1.25	1.05	1.13	1.25	1.00	1.00
<u>Pachysandra terminalis</u>	0.03	0.33	0.56	0.27	0.17	0.29	0.23
<u>Pieris japonica</u>	0.85	1.01	0.78	0.77	0.63	1.35	0.79
<u>Rhododendron</u>							
<u> mucronatum</u>	0.50	0.50	0.63	0.50	0.63	0.50	0.38

Plant Injury

0 - No Injury

5 - Dead

and R-1607 at 10 pounds per acre. Unsatisfactory weed control was obtained with trifluralin at 2 pounds per acre. In treated plots, which had neither been rototilled on the date of planting nor planted, the weed population was less than the planted plots.

The liners were examined for injury on October 17, 1963. The data are summarized in Table 2. In most cases the plants exhibited little or no injury. Where some injury was observed on a particular variety, this slight injury was noticed on some plants in all treatments. Examples of this are Chamaecyparia pisifera squarrosa, Euonymus fortunei, and Leucothoe catesbaei. This is most likely due to transplanting shock.

Summary

Six pre-transplant herbicides or combinations were incorporated in the soil. Twenty different narrow- and broadleaf evergreen varieties were transplanted in these beds.

SD-7961 and dichlobenil at 3 pounds per acre, EPTC, EPTC plus Sun 60 wax and R-1607 at 10 pounds per acre gave satisfactory weed control. Little or no injury was noted on the liners. Where injury was present, it appeared to be due to transplanting shock.

THE RESIDUAL EFFECT OF EPTC ON COVER CROPS IN NURSERY SOILS

FOLLOWING CONTROL MEASURES

FOR AGROPYRON REPENS L. AND ARTEMISIA VULGARIS L.

A. M. S. Pridham¹

EPTC (Eptam) has been incorporated into soils used for nursery crops to successfully control Agropyrons repens L., quackgrass, and also to control Artemisia vulgaris L., mugwort or chrysanthemum weed as it is known to nurserymen.

Rates of 5 to 15 pounds aia (active ingredient per acre) from 6 lb. gallon liquid formulation or similar rates from 5% granular formulations applied to recently rototilled soil, has reduced these weeds by 90% or more. Post treatment practices of firming the soil, covering the soil with plastic, watering by $\frac{1}{4}$ inch or more irrigation to seal or to thoroughly wet the soil through the loosened soil-herbicide mixture have been more successful than applying the EPTC to a weedy soil surface and rototilling once over.

The following nursery crops grown in pots as young 1-2 year liners have survived after planting within a week of the date of EPTC incorporation: Juniperus horizontalis, Taxus media hicksii, Forsythia intermedia, Euonymus fortunei, Hedera helix, also petunia and the indicator crops beans (red kidney), oats and perennial or annual ryegrass. Injury as discoloration, dwarfing and/or death was noted occasionally with petunia (potted) and frequently with 10 and 15 lb. aia EPTC for beans, oats and ryegrass. Injury was noted in 1963 with nursery crops planted bare root, when EPTC, 15 lb. aia was sprayed on the roots or mixed with the soil used for backfill at planting time. There is little if any evidence to indicate poor growth of nursery stock planted 3 months or more after incorporating EPTC in amounts adequate for control of quackgrass (Agropyron repens), or chrysanthemum weed (Artemisia vulgaris).

In 1963 field soils of silty clay loam type were treated with EPTC, both liquid and granular formulations, at 5, at 10, and at 15 lb. aia a) early in July, plot 101 b) August, plots 110, 111, and c) September, plots 70, 77. These represent soils at normal moisture, July, plot 101, low moisture or dry to plow depth, August and low moisture; i.e. inadequate to support germination of oats, etc. without irrigation, September 1963, plots 70 and 77, dry soil. Plot 110 received 1 acre inch of precipitation immediately after incorporation and first planting. Soil kept dry for 7 days, plot 111, after EPTC incorporation and then given 1 acre inch of water.

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Table 1. Height of oats in inches, A in surface soil sample, B in subsurface, 4-6 inches, sample¹

Condition	Plot	Control	Spray ais ²			Granular ais ²		
			5	10	15	5	10	15
Dry, Normal Soil (Sept.)	A 70	8.3	5.6	7.5	---	7.5	---	---
	A 77	8.7	7.9	6.6	4.0	7.0	---	---
Dry Soil Irrigated (Aug.)	A 110	8.8	0.8	0.8	0.1	0.1	0.5	0.5
	A 111	7.1	2.2	1.5	0.2	0.8	0.8	0.6
Normal Soil (July)	A 101	8.0	7.4	2.0	---	3.0	2.5	---
Dry Soil Watered (Sept.)	B 70	9.6	8.2	7.6	2.3	8.3	0.2	---
	B 77	7.6	7.6	7.1	6.3	8.4	0.2	---
Dry Soil Irrigated	B 110	8.6	1.2	1.0	0.2	0.2	1.0	1.3
	B 111	9.9	3.5	2.3	2.6	2.2	1.0	1.3
Normal Soil (July)	B 101	8.9	8.6	2.2	4.6	5.3	2.2	---

Table 2. Weight of oats in grams, A from surface soil samples, B from subsurface, 4-6 inches, samples³

Dry Soil Watered (Sept.)	A 70	2.2	2.5	1.9	0.5	2.4	0.3	0.0
	A 77	2.5	2.6	2.5	2.3	1.2	0.0	0.0
Dry Soil Irrigated (Aug.)	A 110	3.8	0.2	---	0.1	---	---	---
	A 111	2.0	---	---	0.4	---	---	---
Normal Soil (July)	A 101	2.3	2.4	0.4	0.6	0.5	0.2	---
Dry Soil Watered (Sept.)	B 70	2.6	2.4	2.7	0.9	2.5	0.4	1.2
	B 77	2.2	2.2	2.2	2.0	2.4	0.5	0.0
Dry Soil Irrigated (Aug.)	B 110	2.7	0.3	---	0.2	---	---	0.2
	B 111	3.3	0.9	---	0.4	---	---	---
Normal Soil (July)	B 101	2.1	2.7	---	1.9	2.0	---	---

1. Differences significant if treatment mean is 5.5 or less, i.e., treatment causes significant response expressed as height of oat plant in inches. Sample of 10 plants per culture, 3 culture/treatment.
2. Active ingredient per acre.
3. Differences from control are significant if readings of treatment are 1 or less expressed as green weight in grams of top where samples are of 10 plants per culture, 3 cultures/treatment. All top growth included whether original or regrowth. Oats will produce a second shoot if first one is damaged.

Table 3. Weight of buckwheat in grams (10 plants) calculated from mean value, A surface soil sample, B from subsurface, 4-6 inches, sample¹

Condition	Plot	Control	Spray aia ²			Granular aia ²		
			5	10	15	5	10	15
Dry Soil	A 70	10.0	1.1	5.6	5.7	2.0	7.8	1.6
Watered (Sept.)	A 77	5.9	4.3	4.3	3.5	5.0	4.0	2.7
Dry Soil	A 110	9.2	2.3	3.3	2.1	2.9	2.6	2.0
Irrigated (Aug.)	A 111	7.1	3.4	3.6	4.6	2.8	0.0	1.0
Normal Soil (July)	A 101	5.2	5.5	4.0	4.3	7.0	2.6	1.8
Dry Soil	B 70	6.3	1.2	6.5	5.0	1.3	7.0	5.3
Watered (Sept.)	B 77	5.7	5.2	5.7	5.1	5.0	4.4	7.0
Dry Soil	B 110	9.1	2.6	3.3	3.0	5.8	3.5	3.7
Irrigated (Aug.)	B 111	7.0	5.1	4.0	5.0	7.7	4.0	5.0
Normal Soil (July)	B 101	4.9	6.5	4.6	3.3	5.5	3.0	2.5

Table 4. Influence of soil type on response of oat and buckwheat to incorporated Eptam. Culture grown under mist. Data in grams for 10 plants, 4 replicates.

Soil type	Oat					Buckwheat				
	Control	Spray aia ²		Granular aia ²		Control	Spray aia ²		Granular aia ²	
	0	5	15	5	15	0	5	15	5	15
Bank sand	1.9	1.4	1.1	1.2	1.0	2.9	2.7	2.3	2.2	2.5
Greenhouse soil	5.9	1.2	---	---	---	9.4	5.0	3.1	0.9	0.4
Native peat	2.8	0.0	0.0	0.0	0.0	4.6	2.8	0.9	1.5	1.6
Sandy loam	1.6	1.2	1.0	1.2	0.0	2.2	2.3	2.6	2.3	1.1

In October, half of each plot was re-rototilled and replanted. Three soil samples were taken from each treatment on October 1. The samples came from the upper 2 inches of soil, and from the 4-6 inch level immediately below the soil surface. Two to 4 inches of soil was discarded. Crops used as

1. Differences are significant if readings of treatment mean are 2.5 gram or less expressed as gram green weight of tops for control plots, 3 replicates.
2. aia - Active ingredient per acre.

indicator crops included oats, buckwheat and ryegrass. In field plots these were planted immediately following treatment and again after 3 and after 7 days. Soil samples were mixed in a small 5 gallon cement mixer and placed in "Market Pac" plastic trays for seeding, and placed in the greenhouse under mist. Data presented in the tables are from soil samples.

Test crops grew normally outdoors in untreated soil, oats reaching 18 inches and rye 10 inches. Beans reached mature pod stage, and buckwheat 12 inches. Frost on September 14 killed the summer plantings; hence data is limited to that from soil samples under greenhouse conditions. November growth outdoors of oats and of rye is normal in all except the granular formulations at 15 lb. aia and in all treatments in dry soil subsequently given heavy irrigation.

Summary

EPTC incorporated into the soil at rates adequate to control Agropyron repens L. and Artemisia vulgaris L. may depress the growth of such cover crops as oats and buckwheat. This is particularly true in present tests when soil is treated and then irrigated 1 acre inch or more to wet the soil through the zone of EPTC incorporation. Treatment of moderately dry soil with $\frac{1}{4}$ acre inch of water for purposes of encouraging germination of cover crops did not reduce growth of cover crops at the 10 aia rate when liquid formulation was used, but did eliminate growth at 10 aia from granular formulation EPTC. Field plantings of cover crops made in freshly rototilled soil are growing in all but the 15 aia rate EPTC treatment.

The use of 15 lb. aia EPTC for weed control in nurseries infested with Agropyron repens L. and/or with Artemisia vulgaris L. is probably not necessary. More attention should be given the possibility of fall treatment, 5 lb. aia, followed by early spring treatment, 5 lb. aia EPTC a few days prior to planting nursery crops other than gladiolus and other definitely susceptible or bare root nursery stock such as Ilex crenata. Thorough incorporation of EPTC is important for effective control of perennial weeds such as quackgrass and mugwort.

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"Control of Artemisia vulgaris Around Established Shrubs"

Alton E. Rabbitt and Robert N. Cook¹

The nursery of the National Park Service, National Capital Region, has been heavily infested with Artemisia vulgaris L. for some time. A. vulgaris, chrysanthemum weed, has been moved from the nursery to various parks as trees and shrubs have been transplanted. This weed has been able to persist in areas which are cultivated several times each season and has spread to become a serious weed in lawn areas. The spreading of this weed throughout the park system and its persistence once established combine to make a good, inexpensive control necessary.

Experimental Procedures

The first of two experiments looking for control measures for this weed was set up in an old, established lilac bed in West Potomac Park.

A duplicated series of 4 by 12-foot plots were established. The chemical or chemicals for each plot were measured and water added to make approximately one quart, which was sufficient to wet the weed foliage to the point of run-off. Treatments were:

1. Amitrole at 8 pounds per acre.
2. Silvex at 8 pounds per acre.
3. Amitrole at 4 pounds and silvex at 4 pounds per acre.
4. Oil soluble amine of 2,4-D at 4 pounds per acre.
5. Sodium arsenite at 11 pounds per acre.
6. Dicamba at 2 pounds per acre.
7. Dicamba at 1 pound and silvex at 4 pounds per acre.
8. EPTC at 15 pounds per acre.
9. Check, no treatment.

Treatments were made in mid-April when the chrysanthemum weed was about 6 inches high. The EPTC treated plots were hoed, debris removed, sprayed, and raked in an attempt to incorporate the material to a depth of at least one inch. All other treatments were post-emergence. Sodium arsenite was repeated in mid-May. Estimates of control and injury to the lilacs were made periodically throughout the season.

The second experiment was conducted at the Region Nursery. Each plot consisted of the area immediately surrounding plants of several genera. The weeds were sprayed with a knapsack type sprayer using care to avoid getting herbicide on the ornamental plants. The rates of chemical and water was the same as in the previous experiment. The treatments were silvex, amitrole-silvex mix and sodium arsenite. Application was made in mid-May. The following trees or shrubs were treated:

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1. Camellia sasanqua
2. Rhododendron hybrid (Glendale azelia)
3. Buxus sempervirens suffruticosa
4. Viburnum tomentosum
5. Ilex crenata convexa
6. Pinus strobus
7. Tilia cordata
8. Taxus cuspidata

Results

To date no injury to the lilacs has been observed from any herbicide. Varying degrees of control were observed with the several herbicides.

Initial control by amitrole was very poor. However, control or injury to the weed increased as the season progressed to mid-summer and from then until the close of the growing season good control was observed.

Good control was achieved with silvex from April through mid-summer. Later the Artemisia vulgaris showed signs of recovery and the degree of control could only be considered fair by the end of the growing season.

The combination of amitrole and silvex seemed to retain the advantages of both. The mixture gave better control early in the season than amitrole alone and better control later in the season than silvex alone.

All vegetation sprayed with sodium arsenite was killed within a few days after treatment. However, four weeks later there was an estimated 50 percent recovery. Most of this regrowth was from rhizomes.

The oil soluble amine of 2,4-D produced fair control the first eight weeks after application; later, considerable recovery was observed. Fair control was achieved with dicamba eight weeks after treatment but final control was unsatisfactory. The dicamba-silvex mixture gave good control until late in the season when some recovery was observed. The results obtained with EPTC can best be described as variable. In one replication control was good all season, in the other control was very poor.

In terms of the seasonal average both silvex and the amitrole-silvex mix gave very good control, estimated at almost 85 percent. The dicamba-silvex mix was rated as good with an estimated 78 percent control. The control achieved with the other materials was not considered satisfactory, 60 percent or less.

Of the 36 plants treated at the nursery two were killed. These were azelias treated with silvex. No other injury could be attributed to herbicide treatments.

Control with silvex was not as good at the nursery as it was in the lilac bed. Initial reaction was delayed and control was never rated better than good. The seasonal average estimated control was 76 percent.

The results obtained with the amitrole-silvex mixture at the nursery were similar to those at the lilac bed. The degree of control increased as the season progressed with perfect control at certain plants. The average estimated percent control for the season was 85 which was considered very good.

As at the lilac bed, sodium arsenite killed the tops of the Artemesia vulgaris very quickly. Regrowth from below ground parts was such that recovery was complete within six weeks.

Summary and Conclusion

Artemesia vulgaris in a lilac bed and the National Capital Region nursery was treated with various chemicals or combinations of chemical in an effort to eradicate the weed. The most promising treatments were silvex alone or in combination with amitrole. The combination of amitrole with silvex apparently reduced the hazard to other plants, increased the effective time, and is more economical.

Others which might be useful under certain circumstances are sodium arsenite and EPTC. Sodium arsenite could be very effective where treatment could be repeated at monthly intervals or where an immediate effect is desired. EPTC appears to have promise where it can be thoroughly incorporated in the soil.

The oil soluble amine of 2,4-D may prove useful at a rate higher than the 4 pounds per acre used here.

Amitrole is too slow acting to be useful alone, but in combination appears to give increased residual action.

Dicamba alone or in combination has not shown any real potential as a herbicide for control of Artemesia vulgaris.

The results of these tests indicate that chemical control of Artemesia vulgaris in shrubbery beds should be practical.

THE USE OF EPTC FOR CONTROL OF ARTEMESIA VULGARIS L.

Arthur Bing¹ and A. M. S. Pridham²

Experiments carried out in 1962 showed that EPTC (ethyl N,N-di-n propylthiolcarbamate) at 15 lb aia thoroughly incorporated into the soil has great promise as a control for Artemisia vulgaris L., mugwort (1). If EPTC was not adequately mixed into the soil containing Artemisia stems, control was not satisfactory. Many commercial nurseries have an Artemisia problem and are very much interested in the possibility of a relatively inexpensive preplant soil treatment that would eliminate or at least give good control of Artemisia vulgaris and also Agropyron repens (L.) Beauv., quackgrass.

Materials and Methods

In the fall of 1962 and the spring of 1963, EPTC* treatments were made in several nurseries under variable soil, weed and crop situations. In all treatments reported in this paper 5% or 10% granular EPTC was used because of ease in handling and grower preference for granulars in the New York area. The granular EPTC was thoroughly incorporated into the soil by rotovator, rototiller or disk harrow. Some soils had been tilled before applying the EPTC. Other areas had been cleared of nursery stock and the granular EPTC was applied over the weedy soil and all chopped in at one time. Areas to be treated varied from slightly infested to solid mats of Artemisia. Some areas were planted soon after treatment, others remained fallow for a year or more.

Discussion of Results

In the fall of 1962 an acre plot of Artemisia infested land at Imperial Nursery was cleared of nursery stock and treated by the grower with 15 lb aia EPTC (300 lb 5% gran EPTC). The granules were quickly incorporated into the loose light soil by disking. In the spring of 1963 the land was again disked several times. On May 28, 1963 one 2000 sq ft plot in the field was retreated with 15 lb aia EPTC and another 2000 sq ft plot was treated with 15 lb aia Stauffer RL607 (N-propyl di-n-propylthiolcarbamate). In the summer of 1963 there were a few traces of live Artemisia in the field but most Artemisia stems in the soil were dead. Convolvulus arvensis L., field bindweed, and Scleranthus annuus L., knawel, were not adequately controlled and made visible growth during the late summer. Later in the summer a cover crop of oats was sown in the field. The growth of oats was fairly good except in the two retreated plots where growth was very poor.

At Hicks Nursery, an old Artemisia infested nursery block was cleared and the land plowed and disked. On May 7 the area was treated with 15 lb aia EPTC granular and immediately rototilled. In one month the 5000 sq ft plot

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* The authors wish to thank the Stauffer Chemical Company for supplying the materials used in this investigation.

was planted with young Pinus thunbergii, black pine, liners. During the summer the pines made good growth and there was very little regrowth of Artemisia. However, Portulaca oleracea, purslane, field bindweed, and other weeds came in because there was no cultivation or post-plant herbicide treatments.

Another heavily infested area in the same nursery was cleared of the few remaining nursery plants on May 13, 1963. On this same day before treatment, random 1 sq ft areas were sampled to a depth of 6 inches and weights of Artemisia stems determined. The average fresh and dry weights are shown in Table 1. There was a thick mat of Artemisia three inches tall over the whole area. Areas of 1000 sq ft received the following granular treatments: EPTC 15 lb aia, EPTC 20 lb aia, EPTC 10 lb aia and RL607 15 lb aia. The granules were rototilled into the dry soil along with the Artemisia. It rained the evening of May 14. Visual observations and results obtained by repeating the soil sampling as recorded in Table 1, show that Artemisia control was practically complete in the 20 and 15 lb aia EPTC plots, fair in the 10 lb aia EPTC and poor in 15 lb aia RL607 plots.

At Hickory Hill Nursery two areas were treated with EPTC 15 lb aia. One area was treated in mid-May. Control of most weeds was good but azalea var. Hinodegiri planted 2 weeks after treatment showed considerable root injury later in the summer. Another area heavily infested with Agropyron repens, quackgrass and Artemisia was treated with EPTC 15 lb aia and rototilled in June: weed control was very good.

An area in the nursery of the State University Agricultural and Technical Institute at Farmingdale was treated with EPTC 15 lb aia per acre and rotovated on May 7. Young liners of Taxus cuspidata and Ilex crenata convexa were planted in the area May 21. Crop growth during the season was good. Purslane became a problem in some areas during the summer. The weedy areas were retreated and the whole area was cultivated. Control of purslane was again only temporary.

At Green Valley Nursery most of the beds in the nursery sales area were treated with EPTC granular and rototilled in mid summer. Many kinds of balled and burlaped plants were heeled in or placed on the surface one month later. There was no crop injury and Artemisia and general weed control was very good.

Summary

EPTC granular at 15 lb aia rototilled into dry soil gives good control of Artemisia vulgaris. The more thorough the incorporation the better the results. Portulaca oleracea, Scleranthus annuus, and Convolvulus arvensis can still be a problem after treatment. Strawberries and Hinodegiri azaleas were injured when planted two weeks after treatment. Ilex crenata convexa and Taxus cuspidata grew normally when planted 2 weeks after treatment, Pinus thunbergii grew normally when planted one month after treatment. There should be a waiting period after treatment for most crops. Fall treatments followed by spring planting is suggested. Until more complete crop tolerance data are available growers should check the tolerance of their crops in their soils. This fall a wide variety of liners were planted 2-4 weeks after soil treatment to study tolerance.

Table 1. *Artemisia* control Hicks Nursery 1963.

Herbicide	Rate	Fresh Weight*		Dry Weight	
		Treatment	Treatment	Treatment	Treatment
		Before**	After***	Before	After
		<u>grams</u>	<u>grams</u>	<u>grams</u>	<u>grams</u>
EPTC	10	139	31	30	1
	15	207	2	31	1
	20	156	6	36	2
RL607	15	128	32	32	8

* Averages of 3 samples **May 13 ***November 22

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PRELIMINARY RESULTS WITH PICOLINIC ACID¹
 IN CONTROLLING POLYGONUM CUSPIDATUM SIEB. AND ZUCC.

A. M. S. Pridham²

The root system of Polygonum cuspidatum is made up of 1/4 to 2 inch diameter rhizomes of fleshy to woody character. True roots also become woody and extend to a foot and more in depth and 3 feet or more in length. The network of rhizomes and roots forms a dense interwoven mass difficult to grub out, and in large patches requires heavy rotary or chisel type equipment to work the soil.

Regrowth from the numerous buds on young rhizomes and from the several large buds at the crown of individual clumps, is stimulated by cutting back the tops or by cutting the rhizomes or "roots" with hoe or spade.

During 1962 Fenac was used as a basal spray so that the herbicide might move into the crown and root system without killing the tops and thus stimulating bud break. Clumps treated with Fenac in 1962 and left without treatment in 1963 produced shoots of dwarf size and bearing distorted foliage characteristic of Polygonum response to Fenac at 5-10 lbs. aia (active ingredient per acre).

Picolinic Acid (Tordon) became available as formulations 22K and 101 (Picolinic 2,4-D) during summer 1963. Basal sprays at 1, 2 and 3 aia Picolinic Acid; 1 quart per 100 square feet of Polygonum stand was used on at least two 25 sq. ft. clumps in each of three locations (Niles, Ithaca, and Richford, N. Y.). Three or more root samples were taken 3 weeks after treatment and again in late October. In all samples rhizomes showed response at the crown and later for distances of a foot or more along the rhizomes.

Injury consisted of bud and pith discoloration, excess callus growth so that bark was split; later stages resulted in decay of rhizome and root tissue, also death of buds.

When the first flush of growth was cut in late June, young regrowth was sprayed in July and death of foliage followed quickly. Rhizomes also were damaged as indicated above.

Successive root samplings indicated that Tordon continued to stimulate callus growth and bud injury progressed even though tops were dead from early frost, September 14, and only basal treatment as used originally.

1. Picolinic Acid -- 4-amino-3,5,6, trichloro picolinic acid formulated under trade name Tordon 22K.
2. Professor, Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, N. Y.

Tordon purposely sprayed on woody ornamentals resulted in serious trouble in young growth in Juniperus horizontalis, Taxus media hicksii, Euonymus fortunei, and Forsythia intermedia. In field plots where Polygonum was growing in moist soil of a drainage field of a septic tank, and roots of maple, forsythia and lilac extended into Tordon treated soil, death of the side of the plants adjacent to Tordon treatment followed.

Benzac, Fenac, Amiben, Silvex, Amitrol and Casaron used at 5 lb. aia, or 10 lb. aia basal spray, or surface granular did not induce a lethal response equal to that which follows the use of 1 lb. aia Tordon as basal spray; however, bud break and regrowth were retarded as compared to the untreated controls.

Foliar treatment is equally as good as basal treatment but hazardous to nearby plants. Foliar treatment to young regrowth is especially effective and limits application to mid summer or later when unfavorable reaction by other garden plants is reduced, except where crop roots occupy moist soil and in this case unfavorable response of ornamentals can be anticipated.

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CHEMICAL WEED CONTROL IN TRANSPLANTED ONIONS AND STRAWBERRIES¹S. L. Dallyn and R. L. Sawyer²ONIONS - Methods:

The 1963 program had several objectives: (1) to obtain additional information on Dacthal, particularly on its use very early in the season, (2) a direct comparison of CIPC and Randox under several conditions, and (3) continue the search for superior herbicides for annual grass control.

Early Harvest plants were set in the field April 11 and treated with herbicides April 23, May 22 and June 25. In the case of treatments 1 and 2 (Table 1) the first application was immediately before and immediately after setting rather than on April 23. Treatments were replicated six times in paired plots -- one of each pair being a check. This was done to insure similar weed populations for rating and accurate yield comparisons. Granular materials were applied broadcast, the rest as directed sprays. Tillam and R-1607 were soil incorporated with the exception of one treatment of Tillam which was irrigated in.

Weed control ratings were made four times during the growing season. Check plots were hand hoed and weeded in the row to prevent weed competition. Weeds were also removed from treated plots for the same reason but in this case they were pulled in order to keep soil disturbance at a minimum. This operation was done immediately after rating and before application of the next set of treatments. The crop was harvested July 31, yield records obtained, and samples placed in common storage to September 9.

Results and Discussion:

The data are summarized in Table 1. The yield from each treatment should be compared with its own check -- see "Methods". Since the field proved to be highly infested with weeds throughout the whole area, the control ratings can be compared with a check reading of 1 in every case.

Diphenamid was very injurious to yield and storability of onions when used ahead of layby; Paraquat, at layby, had similar effects. None of the other treatments had any effects on yield (or storage). In the few cases where they exceeded the checks this was probably due to weed competition and mechanical damage from hoeing in the checks.

CIPC was superior to Randox in weed control in practically every comparison. This was primarily due to the weakness of the latter on two weeds -- smartweed and pusley, which were very numerous in the experimental area. Dacthal worked very well applied early in the spring and there was little benefit from using it more than once. Tillam and Amiben continued to look good as layby materials, and Swep gave considerable promise in this regard as well.

¹Paper No. 502, Dept. of Vegetable Crops, Cornell University, Ithaca, N.Y.

²Long Island Vegetable Research Station, Riverhead, New York

Table 1. Effects of a number of herbicide treatments on yield of transplanted Early Harvest onions and on weed control throughout the growing season.

Treatment	Yield - Bu/A		Weed Control Rating ¹			
	Treat- ment	Check	6/7	6/24	7/9	7/22
1. Dacthal w.p. 12 lbs before setting; Radox 6 and 8 lbs.	542	526	5.0	4.8	4.5	4.0
2. Dacthal w.p. 12 lbs. immediately after setting; Radox 6 and 8 lbs.	535	508	5.0	5.0	4.5	4.2
3. Dacthal w.p. 12 lbs. at 2, 5 & 8 weeks	490	524	5.0	4.8	4.8	4.2
4. " " " at 2 weeks; Radox 6 and 8 lbs.	559	535	4.8	4.7	4.8	4.0
5. Dacthal w.p. 12 lbs. at 2 and 5 weeks; Radox 8 lbs.	533	533	4.5	4.6	4.8	4.2
6. CIPC e.c. 4 and 6 lbs; Diphenamid w.p. 6 lbs.	502	497	5.0	4.4	4.0	3.8
7. Radox, gr. 4 and 6 lbs; Diphenamid w.p. 6 lbs.	501	460	4.0	2.0	3.8	3.5
8. CIPC 4 lbs; Diphenamid 6 lbs; Radox 8 lbs.	182	479	5.0	5.0	4.8	4.0
9. CIPC 4 lbs; Diphenamid 6 and 6 lbs.	184	479	5.0	5.0	4.8	4.5
10. CIPC 4 and 6 lbs; Tillam gr. 4 lbs.	466	506	5.0	5.0	4.8	4.4
11. Radox 4 and 6 lbs; Tillam gr. 4 lbs.	522	486	4.2	3.0	3.5	3.0
12. CIPC 4 lbs; Tillam 4 lbs; Radox 8 lbs.	499	521	5.0	5.0	4.6	4.0
13. CIPC 4 lbs; Tillam 4 and 4 lbs.	530	541	5.0	5.0	5.0	4.5
14. CIPC 4 and 6 lbs; Amiben e.c. 4 lbs.	624	562	5.0	5.0	4.8	4.2
15. Radox 4 and 6 lbs; Amiben e.c. 4 lbs.	513	561	3.8	2.2	4.2	3.8
16. Radox 4, 6 and 8 lbs.	568	517	3.2	2.2	2.0	1.0
17. CIPC 4, 6 and 8 lbs.	548	497	4.8	4.8	4.0	2.5
18. Radox 4, 6 and 8 lbs. immediately after irrigation	504	442	3.8	2.2	2.0	1.5
19. Radox 4, 6 and 8 lbs. 2 days after irrigation	521	444	3.8	2.2	2.0	1.2
20. Radox 4, 6 and 8 lbs. immediately prior to irrigation	517	488	4.0	2.0	2.5	1.2
21. Radox 4 and 6 lbs; Tillam 4 lbs. incorp.	530	522	4.0	2.4	3.5	3.0
22. Radox 4 and 6 lbs; Tillam 4 lbs. irrigated in	539	542	4.0	2.2	3.0	2.0
23. Radox 4 and 6 lbs.; Paraquat e.c. 1 lb.	353	521	4.0	3.0	4.5	3.0
24. Radox 4 and 6 lbs; R-1607 gr. 3 lbs.	550	506	4.0	2.5	3.5	3.0
25. Radox 4 and 6 lbs; Swep w.p. 6 lbs.	488	497	4.0	3.0	4.5	4.0

L.S.D. 5%

41

¹ 1 - no control; 5 - excellent

STRAWBERRIES - Methods:

The varieties Midland, Surecrop and Jerseybelle were set in the field April 27, 1962, and treated as outlined in Table 2. The Tillam in treatment #1 was applied the day before setting and incorporated in the soil with a garden

crop response. Yield data were obtained in 1963 following a very severe winter in which considerable crop damage occurred. As a result of this, the yields were considerably below average. Plots were single rows 24 feet long, 14-inch matted row on 34-inch centers. The design was a randomized block, four replications.

Significant variety interactions did not occur so the data were combined to give an average for all three. Surecrop suffered less winter damage than the other two and yielded about 75% of normal; Midland and Jersey-belle were slightly less than 50% of normal.

Results and Discussion:

The results are summarized in Table 2.

Table 2. Effects of herbicides on weed control and crop performance with strawberries.

<u>Treatment</u>	<u>Crop Res¹</u> <u>ponse 1962</u>	<u>Weed Control²</u> <u>Rating, 1962</u>	<u>Yield #1 Fruit</u> <u>Lbs/A, 1963</u>
1. Tillam - 4 lb. gran. inc. before planting	4.0	2.2	3,893*
2. Tillam - 4 lb. gran. inc. 6/22	1.0	3.5	7,403
3. Tillam - 4 lbs. gran. inc. 6/22 & 7/30	1.0	4.0	8,520
4. Tillam - 4 lbs. gran. surface, 6/22	1.0	1.8	8,133
5. Eptam - 4 lb. gran. inc. 6/22	1.0	3.5	9,058
6. Eptam - 4 lb. gran. inc. 6/22 & 7/30	1.0	4.0	9,042
7. Eptam - 4 lb. gran. surface, irrig. in	1.0	3.0	8,822
8. Zytron - 20 lb. gran. 6/22	1.0	3.0	7,861
9. Zytron - 20 lb. gran. 6/22 & 7/30	1.2	3.7	7,341
10. Dacthal - 12 lb. gran. 6/22	1.0	3.5	8,838
11. Dacthal - 12 lb. gran. 6/22 & 7/30	1.0	3.6	7,298
12. Diphenamid - 6 lb. w.p. 6/22	1.0	3.8	8,219
13. Diphenamid - 6 lb. w.p. 6/22 & 7/30	1.0	4.1	6,973
14. Trifluralin - 3 lb. e.c. 6/22	1.5	3.8	8,448
15. Trifluralin - 3 lb. e.c. 6/22 & 7/30	2.0	4.1	6,450*
16. Check	1.0	1.0	8,558

¹ 1-no injury
5-severe injury

² 1-no control
5-excellent control

*significantly
different from check

In 1962 severe plant damage from Tillam used before planting and slight to moderate early damage from Trifluralin was noted. This was reflected in lowered yields in 1963. Tillam and Eptam continued to look good as strawberry herbicides; Dacthal and Diphenamid gave promising results. These four materials are currently being studied in considerable detail regarding frequency and timing of application.

Summary: 1. Excellent weed control in onions throughout the growing season was obtained from early application of Dacthal followed by Randox.

2. In practically all comparisons between Randox and CIPC, the latter was a more effective material in controlling weeds in onions.

3. Tillam, Amiben and Swep all gave good control of annual grasses when used at layby in onions.

POTATO VINE KILLING IN MAINE - 1962

H. J. Murphy and M. J. Goven^{1/}

The following paper is a progress report of potato vine-killing studies conducted in Aroostook County, Maine during the 1962 growing season. Evaluations of harvested tubers were made during the 1962-63 storage season.

MATERIALS AND METHODS:

Eleven potato vine desiccants were tested at Presque Isle, Maine during 1962. Three materials were in trial for the first time, five compounds for the second season, and all were compared against two approved standard vine-killers in common use in Maine. The purpose of these trials was to determine the effectiveness of new desiccants for potato vine-killing when applied at different dosage levels and to determine subsequent effects on tubers harvested from plots treated with the desiccants at varying rates.

All materials were applied in 90 gallons of water per acre to actively growing potato vines and on the dates indicated on each table. A small compressed air sprayer, equipped with a two-nozzle brush type boom, was used for application to single row plots. Nozzles with fan-type delivery were used in all studies.

Using the relative kill-rating system of 1 to 5 as indicated in the footnotes of each table, ratings were made at two time intervals after the materials were applied, and weighted indices for effectiveness of the materials for vine-killing were prepared for this progress report.

Twenty pounds of harvested tubers from each plot were placed in 50°F. controlled storage for examination during the winter months. Storage examinations consisted of snipping the stem end from each tuber and classifying each tuber as to percent of vascular ring showing discoloration. The stored tubers were also examined for possible external discoloration which might have been caused by the vine-killing chemicals. In addition, tuber samples were also supplied to each company who supplied the desiccants for residue analysis.

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RESULTS AND DISCUSSION:

Data in table 1 indicate the effect of several desiccants on vines and tubers of the Katahdin potato variety. U.C.20299 at the rate of 2.5 pounds of active ingredient per acre, Paraquat at the rate of 1 pint per 90 gallons of water, Diquat at 3 pints per acre, and Ametryne and Atrazine at 4 pounds per acre were all effective for potato vine desiccation in Maine during 1962. All of these five compounds were more effective for vine-desiccation than the two standard materials of sodium arsenite and Premerge (dinitro). All of the five effective materials in table 1 are easy to mix, handle, and clean from the spray equipment after use.

Because the manufacturer of Diquat and Paraquat indicated intentions of seeking F.D.A. clearance for use as potato vine desiccants, additional rate studies were conducted with these compounds. Table 2 presents the results of applying several rates and combinations of Diquat to potato vines. In general, the lower rates of application appear to be about equally as effective as the 3/4 pound rate applied either as a single or split application. The one pound rates of Diquat were effective but probably would be excessive in terms of cost per acre. Notice that the 1/4 pound application applied as a split treatment, plus ML-700 activator was almost as effective as the much higher rates of Diquat.

Table 3 presents a comparison of different rates of Paraquat as compared to the standard, sodium arsenite. In no case was Paraquat as effective as sodium arsenite in this particular study. It would appear from the data presented in table 3 that Paraquat herbicide should be applied at the dosage level of 1/4 or 1/2 pounds per acre with the 1/4 pound level as a single treatment being as good as the same total amount applied in split applications.

Apparently the choice between Paraquat or Diquat for use as a potato vine desiccant is somewhat related to the degree of grass kill as well as their effectiveness as desiccants. Although no ratings were made for grass control our observations favored Paraquat as the better of the two materials. Diquat, however, has been in our testing program for several years, whereas this is our first year of testing for Paraquat. In Maine, we will not express preference for Paraquat over Diquat for vine-killing because they are equally effective and grass in our potato fields at harvest time is a relatively small problem.

Table 1. Effect of Several Chemicals Used for Potato Vine-Killing - 1962

Aroostook Farm, Presque Isle, Maine

		Katahdin Variety ^{4/}				
Material	Treatments ^{1/} Rate per acre	Kill Ratings ^{2/}		Percent Internal Discoloration ^{3/}		
		Aug. 29	Sept. 4	Slight	Medium	Severe
No treatment		1.0	1.0			
U.C.20299 ^{5/}	1.5 LBS.	2.8	3.4	0.6		
U.C.20299	2.0 "	2.6	3.0	1.2		
U.C.20299	2.5 "	3.2	4.0			
Banvel - D ^{6/}	1/4 lb.	2.0	1.8			
Banvel - D	1/2 lb.	2.0	2.4	0.4		
Banvel - D	3/4 lb.	2.0	2.4	0.4	trace	
Dinitro ^{7/}	2 QTS. plus fuel oil-emulsifier	2.4	2.8	trace		
Sodium Arsenite ^{8/}	8 lbs.	3.6	3.8	trace		
Paraquat ^{9/}	1 pint	2.6	4.0	0.4		
Ammonium Sulfate	100 lbs.	2.0	2.2	trace		
Ametryne ^{10/}	4 lbs.	3.0	5.0	trace		
Atraton ^{10/}	"	3.0	5.0			
Diquat ^{2/}	3 pints	3.6	4.4		trace	
Ammonium Nitrate	100 lbs.	2.0	1.8	0.5	trace	
Prometryne ^{10/}	4 lbs.	1.6	2.2	0.3	trace	
	L.S.D. (0.05)	0.2	0.8			
	(0.01)	0.3	1.0			

^{1/} Material applied August 24. All treatments received 4 oz. of Plyac spreader sticker except Premerge. All treatments applied in 90 gals. of water per acre.

- 2/ Kill rating code. (average of five replicates)
1. Poor or no kill of leaves or stems.
 2. Most leaves killed but poor stem kill.
 3. All leaves killed and poor stem kill.
 4. All leaves killed and fair stem kill.
 5. Good kill of both leaves and stems.
- 3/ Average of five replicated samples after four months of storage at 50°F. and 85% R.H. Readings completed January 16, 1963.
- 4/ Planted May 16, 1962 and harvested September 26, 1962.

Source of Materials.

5/	U.C. - 20299	Union Carbide Chemical Co.	(R.B. Seeley)
6/	Banvel - D	Vesical Chemical Corp.	(Geo. Schumaker)
7/	Dinitro (Premerge)	Dow Chemical Co.	
8/	Sodium Arsenite	C. W. Staples Co.	(W. Staples)
9/	Paraquat and Diquat	California Chemical Co.	(R.D. Wessel)
10/	Ametryne - Atratone and Prometryne	Geigy Chemical Corp.	(H. Dave Beakley)

Table 2. Effect of Rate of Diquat Herbicide on Potato Vine-Killing - 1962

Aroostook Farm, Presque Isle, Maine

Katahdin Variety^{1/}

254

Material	Treatments ^{2/}		Kill ratings ^{3/}		Percent internal discoloration ^{4/}		
	Rate per acre 8/25/62	Rate per acre 8/31/62	8/29/62	9/4/62	Slight	Medium	Severe
No Treatment			1.0	1.0			
Diquat	1/4 lb.(1 pt)		3.0	3.8	4.5	0.4	
"	1/2 lb.(1 qt)		3.7	3.8	2.5	0.3	
"	3/4 lb.(3 pts)		3.8	3.8	2.6	0.2	
"	1 lb.(2 qts)		4.2	4.3	1.3		
"	1/4 lb.(1 pt) ^{2/}		2.8	3.5	1.1	0.6	
Diquat	1/8 lb.(1/2 pt) +	1/8 lb.(1/2 pt)	2.0	2.5	3.4		
"	1/4 lb.(1 pt) +	1/4 lb.(1/4 pt)	3.2	3.5	0.6	0.3	
"	3/8 lb.(1 1/2 pts) +	3/8 lb.(1 1/2 pts)	3.0	3.8	1.3		
"	1/2 lb.(2 qts) +	1/2 lb.(2 qts)	3.3	4.8	1.6		
"	1/8 lb. (1/2 pt) ^{2/} +	1/8 lb.(1/2 pt) ^{2/}	3.0	4.2	1.1		
Paraquat	1/4 lb.(1 pt) ^{2/}		3.1	4.0	1.1		
Premerge	2 qts plus 5 gals of fuel oil and 1 pint emulsifier		2.8	2.8	1.6		
Sodium Arsenite	(3 lbs.)		3.5	3.8	1.3		
		L.S.D.(0.05)	0.5	0.7			
		(0.01)	0.7	0.8			
	Temp. 85°F. Weather clear	Temp. 80°F. Weather cloudy					

- 1/ Planted May 16, and harvested Sept. 27, 1962.
- 2/ Materials applied in 90 gallons of water per acre
- 3/ Relative kill ratings. (average of six replicates)
 1. Poor or no kill of leaves or stems.
 2. Most leaves killed but poor stem kill.
 3. All leaves killed and poor stem kill.
 4. All leaves killed and fair stem kill.
 5. Good kill of both leaves and stems.
- 4/ Average of six replicated samples after four months storage at 50°F. and 85% R.H. Readings completed January 18, 1963.
- 5/ ML-700 Paraquat activator used at rate of 1 pint per 90 gals. of water.

Table 3. Effect of Rate of Paraquat Herbicide on Potato Vine-killing - 1962

Aroostook Farm, Presque Isle, Maine

Katahdin Variety^{1/}

256

Material	Treatments ^{2/}		Kill ratings ^{3/}		Percent internal discoloration ^{4/}		
	Rate per acre	Rate per acre	9/4/62	9/10/62	Slight	Medium	Severe
No Treatment	8/28/62	9/4/62	1	1			
Paraquat	1/8 lb.		2	3	2.3	2.7	
"	1/4 lb.		3	4	2.3		
"	1/2 lb.		4	4	3.2	0.6	
"	1/4 lb. ^{5/}		3	4	3.0	0.5	
"	1/16 lb.	+ 1/16 lb.	2	3	4.4	1.0	
"	1/8 lb.	+ 1/8 lb.	2	3	5.3	1.6	
"	1/4 lb.	+ 1/4 lb.	3	4	2.4	1.6	
Sodium Arsenite	6 lbs.		4	5	1.2		

^{1/} Planted May 29 and harvested September 28, 1962.

^{2/} All treatments applied in 90 gallons of water per acre.

^{3/} Relative kill ratings.

1. Poor or no kill of leaves or stems.
2. Most leaves killed but poor stem kill.
3. All leaves killed and poor stem kill.
4. All leaves killed and fair stem kill.
5. Good kill of both leaves and stems.

^{4/} Average of all tubers in a one bushel sample after four months of storage at 50°F. and 85% R.H. Readings completed January 17, 1963.

^{5/} ML - 700 Paraquat activator used at rate of one pint per 100 gals. of water.

RESULTS OF NEW HERBICIDES ON CORN, SOYBEANS AND SNAP BEAN

A. Zaharchuk 1/

Procedure

The test area was planted on sandy loam soil to single rows of Cornell M-4 corn; Lincoln soybeans; and Bountiful snap beans on June 4. The preemergence test was sprayed on June 5 using a hand operated small plot logarithmic sprayer (1) giving four half-dosages. The soil surface was dry with moisture below. Air temperature ranged from 72 to 80°F. Plot size 6 x 60 feet.

The postemergence plots were sprayed on June 18 and 19, using the type sprayer described above. At the time of spraying the corn was 4 to 6 inches high; the soybeans 3 to 4 in.; and the snap beans 4 to 5 in. high; lambsquarters 1 to 1 1/2 in.; mustard 1 to 1 1/2 in.; ragweed 1 to 1 1/2 in.; hedge and field bindweed 4 to 12 in.; quack grass spike to 6 in. The weeds and crops were dry at the time of spraying. The air temperature 75 to 85°F. Plot size 6 x 60 feet.

Results

Many of the thirty seven materials tested lacked herbicidal activity or crop tolerance. Results will be presented on the materials that appear promising for further development.

Pennsalt's B-377 gave very good broadleaf weed control down to the 1 1/2 lb. rate. Soybeans and snap beans were tolerant to this material applied preemergence even at the 12 lb. rate. These crops were not tolerant to the material when applied postemergence.

Stauffer's Eptam-2,4-D gave good broadleaf weed control down to 2 1/4 lbs. Eptam and 1 1/8 lb. of 2,4-D. Corn was tolerant to the material applied preemergence even at the high rate of 18 lbs. Eptam and 9 lbs. of 2,4-D. When applied postemergence rates of Eptam 1 1/8 lb. and 9/16 lb. of 2,4-D gave excellent broadleaf weed control. Corn was tolerant starting at the rate of 2 1/4 lbs. Eptam and 1 1/8 lb. of 2,4-D.

Stauffer's R-1910 and 2,4-D applied preemergence gave excellent broadleaf weed control down to 1 1/2 lbs. R-1910 and 3/8 lb. 2,4-D. Corn was not tolerant to this material when applied postemergence.

1/ Cooperative G.L.F. Exchange, Inc. Research & Development
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Four formulations of DuPont linuron were tested preemergence for comparison on tolerance to corn. Preemergence the 1963 formulation and original material coded 326 at the lowest rate used of $1\frac{1}{2}$ lbs., gave only very slight injury to the corn. The 1962 formulation and linuron L gave more severe injury than the other formulations at the lowest rate used of $1\frac{1}{2}$ lbs.

Geigy atrazine, used as a standard, applied preemergence gave very good broadleaf weed control down to 3 lb. rate. Below this rate, atrazine failed to control field and hedge bindweed. When applied postemergence, very good control was obtained on down to the $3/4$ lbs. rate.

Conclusions

Of the new materials tested Pennsalt's B-377 warrants further testing pre-emergence on soybeans and snap beans. Stauffer's Eptam-2, 4-D and R-1910-2, 4-D warrants further investigation for corn preemergence. DuPont's 1963 formulation of linuron was as safe as the original material coded 326 and much safer to corn than the 1962 formulations or linuron L and warrants further investigation.

Literature Cited

1. Cialone, J. C. and Davis, D. W. Construction and Uses for a Hand Operated Logarithmic Sprayer for Small Plots. Dept. of Veg Crops, Cornell University, VC-115, May 1963.

NUTSEDGE (*Cyperus esculentus*) CONTROL IN CORN - 1963S. N. Fertig^{1/}

Nutsedge (*Cyperus esculentus* L.) is an increasingly prevalent weed in field crops in New York. The rapid take-over of individual fields and the spread from field to field has occurred more rapidly than with any other species.

In growth rate tests with New York strains of nutsedge under greenhouse conditions, individual seedlings yielded an average of 152 tubers, 11 weeks after planting (1). The prolific capacity of nutsedge to produce tubers is reported from Minnesota where a single tuber, within a year, produced 6900 new tubers and more than 1900 plants (2). The 6900 tubers were produced the fall of the first season, and the 1900 plants the spring of the next. On heavily nutsedge infested soils in New York, up to 575 tubers have been counted in one square foot of soil, 12 inches deep.

METHODS AND PROCEDURE

During the 1963 season, three separate experiments were conducted on nutsedge control in field corn. Herbicides were applied as soil incorporated treatments and as pre-emergence and post-emergence treatments alone and in combination with incorporated treatments. The soil incorporated treatments were applied 3 days prior to corn planting and incorporated by double discing. The pre-emergence treatments were applied one day after planting and the post-emergence treatments, alone and in combination with incorporated, 17 days after corn planting. The nutsedge plants averaged 3 to 5 inches tall when the post-emergence treatments were applied. One series of treatments (Table 4) were duplicated to compare control with and without cultivation.

A randomized block design with four replications was used. Each plot consisted of 6- 30-inch rows of corn, 30 feet long. All treatments were applied in 30 gallons of water per acre.

The total rainfall and average temperature for 7-day periods prior to and after treatment are shown in Table 1.

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Table 1

<u>Total Rainfall and Average Mean Temperatures</u>		
<u>Incorporated treatments</u>	<u>Total rainfall (inches)</u>	<u>Average mean temp. ° F.</u>
14 days prior to treatment	0.54	51
7 days prior to treatment	0.39	65
7 days after treatment	1.04	67
14 days after treatment	0.47	60
<u>Pre-emergence treatments</u>		
14 days prior to treatment	0.90	54
7 days prior to treatment	0.01	65
7 days after treatment	1.12	67
14 days after treatment	0.39	61

RESULTS AND DISCUSSION

Incorporated Treatments

The nutsedge control ratings, average stand of corn on the harvested rows and yields of shelled corn for treatments receiving no cultivation are reported in Table 2.

The greatest reduction in nutsedge was obtained where all or part of the treatment was incorporated prior to planting.

Tillam alone at 4 and 6 pounds was weak on control but the 6 pound rate caused sufficient retarding effect on the nutsedge to minimize competition to the corn. The control of annual broadleaved species was very poor, even at the 6-pound rate. The broadleaved and annual grass competition at the 4-pound rate is reflected in corn yields.

Tillam + 2,4-D resulted in poorer control of nutsedge than Tillam alone at the same rate of chemical per acre. The combination was slightly more effective on annual broadleaves but no more effective on annual grasses.

Atrazine applied post-emergence gave very poor control of nutsedge. The 3 pound rate was no more effective than the 1-pound rate. All rates gave good to excellent control of annual broadleaves but only the 3-pound rate satisfactorily controlled annual grasses.

Split treatments of Tillam + Atrazine and Eptam + Atrazine resulted in very good seasonal control of nutsedge. The control with Eptam was somewhat better than with Tillam. Eptam + 2,4-D iso-octyl ester incorporated gave good control of nutsedge, fair to good control of annual broadleaves and very good control of annual grasses. Annual grass control was significantly better with Eptam + 2,4-D iso-octyl ester than with Tillam + 2,4-D low volatile ester.

Table 2
NUTSEDGE CONTROL RATINGS AND YIELDS OF GRAIN CORN
No Cultivation

Treat. No.	Chemical	Rate/A. lbs. a.i.	Method of treatment	Nutsedge control ratings*		Yield of shelled corn Bu/A.	Sta pla
				7-12-63	9-16-63		
1	Tillam	4.0	Incorporated**	5+	4+	29.2	2
2	Tillam	6.0	Incorporated	7+	6+	53.3	2
3	Tillam + 2,4-D LV ester	3 + 1	Incorporated	3	4	43.6	2
4	Tillam + 2,4-D LV ester	4 + 1	Incorporated	3	3++	39.8	2
5	Atrazine	1.0	Post-emergence	1	0	29.0	2
6	Atrazine	2.0	Post-emergence	1	3	51.2	2
7	Atrazine	3.0	Post-emergence	1	1+	43.3	2
8	Prometryne, 150E	2.0	Post-emergence	1	0	19.7	1
9	Prometryne, 150E	3.0	Post-emergence	1	1	13.8	1
10	Prometryne, 150E	2.0	Post-directional	-	0	25.6	2
11	Prometryne, 150E	3.0	Post-directional	-	0	29.2	2
12	Tillam	3.0	Incorporated	7	6+	58.6	2
	+						
	Atrazine	2.0	Post-emergence				
13	Eptam	3.0	Incorporated	9	9	69.4	2
	+						
	Atrazine	2.0	Post-emergence				
14	Eptam	3.0	Incorporated	8+	9	69.0	2
	+						
	Atrazine	1.0	Post-emergence				
15	Eptam	2.0	Incorporated	7+	8	65.6	2
	+						
	Atrazine	2.0	Post-emergence				
16	Prometryne + surfactant	2.0	Post-emergence	1	0	26.2	1
17	Prometryne + surfactant	3.0	Post-emergence	2	0	16.8	1
18	Eptam + 2,4-D (iso-o.e.)	2 + 1	Incorporated	8	6+	55.4	2
19	Eptam + 2,4-D (iso-o.e.)	4 + 2	Incorporated	8+	8	67.6	2
20	Cultivated	2 times	Post-emergence	-	6+	49.6	2
21	Cultivated	3 times	Post-emergence	-	6	49.4	2
22	Check - not cultivated	0		-	0	13.0	2
23	2,4-D amine	4.0	Incorporated	1	0	36.8	2

* 0 = no control; 10 = complete control.

** Incorporated treatments: 2 discings with tandem disc, 3 to 4 inches deep, opposite directions.

Table 3
 NUTSEDGE CONTROL RATINGS AND YIELDS OF GRAIN CORN
 One Cultivation on all Plots

Treat. No.	Chemical	Rate/A. lbs. a.i.	Method of treatment	Nutsedge control ratings*		Yield of shelled corn. Bu/A. at 15% moisture	Stam plan
				7-12-63	9-25-63		
1	Tillam	4.0	Incorporated**	7+	8++	63.2	25
2	Tillam	6.0	Incorporated	7+	9	72.0	27
3	Tillam + 2,4-D LV ester	3 + 1	Incorporated	4	8	80.1	25
4	Tillam + 2,4-D LV ester	4 + 1	Incorporated	6	8+	76.5	26
5	Atrazine	1.0	Post-emergence	2	6+	66.3	26
6	Atrazine	2.0	Post-emergence	0	7++	66.6	25
7	Atrazine	3.0	Post-emergence	0	8+	68.4	25
8	Prometryne, 150E	2.0	Post-emergence	0	4++	44.7	20
9	Prometryne, 150E	3.0	Post-emergence	2	3++	34.4	15
10	Prometryne, 150E	2.0	Post-directional	-	5	53.0	25
11	Prometryne, 150E	3.0	Post-directional	-	5+	55.3	24
12	Tillam	3.0	Incorporated	8+	9	72.3	25
	+						
	Atrazine	2.0	Post-emergence				
13	Eptam	3.0	Incorporated	9	9+	75.0	25
	+						
	Atrazine	2.0	Post-emergence				24
14	Tillam	3.0	Incorporated	7	8	69.9	
	+						
	Atrazine	1.0	Post-emergence				
15	Eptam	2.0	Incorporated	7	9	67.3	25
	+						
	Atrazine	2.0	Post-emergence				
16	Prometryne + surfactant	2.0	Post-emergence	5	4++	47.4	20
17	Prometryne + surfactant	3.0	Post-emergence	5	3++	31.6	14
18	Eptam + 2,4-D (iso-o.e.)	2 + 1	Incorporated	7+	8	60.1	24
19	Eptam + 2,4-D (iso-o.e.)	4 + 2	Incorporated	9+	9+	69.9	23
20	Cultivated	2 times	Post-emergence	-	5	45.6	24
21	Cultivated	3 times	Post-emergence	-	7	54.2	24
22	Check - not cultivated	0	-----	-	0	20.2	24
23	2,4-D amine	4.0	Incorporated	0	5	55.0	25

* 0 = no control; 10 = complete control.

** Incorporated treatments; 2 discings with tandem disc, 3 to 4 inches deep, opposite directions.

Table 4
NUTSEDGE CONTROL RATINGS AND YIELDS OF GRAIN CORN

Treat. No.	Chemical	Rate/A. lbs. a.i.	Method		Nutsedge control ratings*		Yield shell corn Bu/A at 15% H ₂ O
			of treatment	Cultivations	7- 12-63	9-30-63	
1	Eptam + Atrazine	2.0 1.0	Incorporated*	none	8	5++	57.9
2	Eptam + Atrazine	3.0 1.0	Incorporated	none	9	9	61.1
3	Prometryne, 150E	2.0	Pre-emergence	none	0	0	32.6
4	R-1910 + 2,4-D	2 + 1/2	Pre-emergence	none	1	1+	27.8
5	R-1910 + 2,4-D	4 + 1	Pre-emergence	none	1+	1	33.8
6	Eptam + 2,4-D	2 + 1	Pre-emergence	none	0	0	28.0
7	Eptam + 2,4-D	4 + 2	Pre-emergence	none	3	1++	40.5
8	SD-7961 + Atrazine	1.0 1.0	Incorporated	none	8	7	34.9
9	H-95-1	1.5	Incorporated	none	0	0	28.0
10	N-3446	4.0	Pre-emergence	none	0	1+	27.8
11	R-4572	6.0	Incorporated	none	3	5++	20.2
12	Eptam + Atrazine	2.0 1.0	Incorporated	one	4	9	65.4
13	Eptam + Atrazine	3.0 1.0	Incorporated	one	4	9	79.8
14	Prometryne, 150E	2.0	Pre-emergence	one	5	6	48.6
15	R-1910 + 2,4-D	2 + 1/2	Pre-emergence	one	4	5++	48.0
16	Eptam + 2,4-D	2 + 1	Pre-emergence	one	4	5	50.8
17	H-95-1	1.5	Incorporated	one	3	5	48.3
18	Check	none	-----	two	0	8	39.7
19	Check	none	-----	none	0	0	11.2
20	SD-7961 + Atrazine	1.0 1.0	Incorporated	one	8	8	41.0
21	N-3446	4.0	Post-emergence	one	4	5+	43.7
22	Atrazine	1.0	Late post-emerg.	two after 2nd cult.	-	9	48.9
23	R-1910 + 2,4-D	4 + 2	Incorporated	one	9++	9+	67.9

* 0 = no control; 10 = complete control.

** Incorporated treatments: 2 discs with tandem disc, 3 to 4 inches deep, opposite directions.

2,4-D amine at 4 pounds incorporated gave no control of nutsedge and poor control of annual broadleaves and annual grasses.

The control ratings, corn stand, and yields of plots receiving chemical treatments plus cultivation are reported in Table 3. A single cultivation increased the final control rating for all chemical treatments and increased the average combined yield of all treatments by 17 bushels of corn per acre. In no instance was the yield of corn reduced by the inclusion of cultivation (Table 2 vs. Table 3).

The first eleven treatments in Table 4, received no cultivation and the last eleven, with the exception of the non-cultivated check, were cultivated. The average yield of shelled corn for the first 11 treatments was 36 bushels while the average yield for the 11 treatments with cultivation was 53 bushels per acre.

The effectiveness of nutsedge control from the treatments in Tables 3 and 4 was best where all or part of the herbicide was incorporated. The pre- and post-emergence treatments were less effective on nutsedge but in general, more effective in controlling annual broadleaves and annual grasses.

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PRELIMINARY OBSERVATIONS OF AMIBEN ALONE AND IN COMBINATION WITH
OTHER HERBICIDES FOR PRE- AND POST-EMERGENCE TREATMENT OF CORN

J. H. Kirch, A. R. Cooke and R. D. Hartl

Considerable interest has developed among weed research workers in reducing the soil residue problem and improving the performance of herbicides presently used for pre-emergence weed control in corn. A number of tests were conducted on the Amchem Research Farm in 1963 to determine whether or not amiben (3-amino-2,5-dichlorobenzoic acid) might be a useful compound for this purpose.

Additional tests of amiben in mixture with other herbicides were applied by other workers in several locations. Results of some of these tests are mentioned in the Discussion section of this paper.

MATERIALS AND METHODS

The Research Farm test area was Readington silt loam treated on April 27 with 2 lb/A of Amitrol-T to control quackgrass. The area was plowed on May 11 and planted with Penn 820 field corn on May 20 and 21. Logarithmic plots replicated three times were laid out 12 feet wide (4 rows) and approximately 45 feet long with three half-dosage distances each approximately 15 feet long.

Pre-emergence treatments were applied on May 21 and 22. Post-emergence treatments were applied on June 7, at which time the corn was 3 to 4 inches tall with most plants in the three-leaf stage. Applications were made in 44 gallons of water per acre.

The annual grasses present on the plot were foxtail (Setaria glauca) and fall panicum (Panicum dichotomiflorum). The annual broadleaf weeds were pigweed (Amaranthus retroflexus), ragweed (Ambrosia artemisiifolia) and lambsquarters (Chenopodium album). Certain plots contained smartweed (Polygonum pennsylvanicum), velvet leaf (Abutilon theophrasti) and jimsonweed (Datura stramonium). About half the area was infested with nutgrass (Cyperus rotundus). No rating was made on this weed.

Rainfall for 20 days following the treatment amounted to 0.94 inches, 0.37 inches falling on May 30 and 0.57 inches on June 4.

RESULTS AND DISCUSSION

Ratings on annual broadleaf weed and grass control were made at each half-dosage distance for each plot on June 25, 26 and 27. Some of these ratings for the pre-emergence treatment are presented in Table 1. Ratings for the post-emergence treatments are pre-emergence treatments are presented in Table 2.

Table 1. Control of annual weeds with several amiben mixtures applied pre-emergence to corn.

Chemical	Rate lb/A	Percent weed control (Average of 3 replications)	
		Broadleaf	Grass
Amiben	3	87	85
Atrazine	2	100	98
Atrazine	1	98	95
Amiben + Atrazine	$1\frac{1}{2} + 1\frac{1}{2}$	98	96
Amiben + Atrazine	$1 + \frac{1}{2}$	95	92
Amiben + Atrazine	$\frac{3}{4} + \frac{3}{4}$	94	89
Amiben + Atrazine	$\frac{1}{2} + 1$	98	87
63-106*	$\frac{3}{4} + \frac{3}{4}$	95	87
Prometryne	2	97	92
Prometryne	1	85	73
Amiben + prometryne	$1 + \frac{1}{2}$	85	75
Ametryne	2	90	97
Ametryne	1	63	53
Amiben + ametryne	$2 + 1$	92	88
Amiben + ametryne	$1 + \frac{1}{2}$	82	75
2,4-D ester (butoxy ethanol)	4	87	75
2,4-D ester (butoxy ethanol)	2	48	33
Amiben + 2,4-D ester	$2 + 1$	87	78
Amiben + 2,4-D ester	$1 + \frac{1}{2}$	65	55
Amiben + 2,4-D ester	$1\frac{1}{2} + 1$	75	62
Randox	8	42	85
Randox	4	33	78
Amiben + randox	$1\frac{1}{2} + 2$	90	93
Amiben + randox	$1 + 1$	57	67
Amiben + randox	$3 + 4$	97	99
Fenac	2	91	81
Fenac	1	86	71
Fenac	$\frac{1}{2}$	72	47
Amiben + fenac	$3 + 1$	92	93
Amiben + fenac	$1\frac{1}{2} + 1\frac{1}{2}$	88	83
Amiben + fenac	$1 + \frac{1}{2}$	78	56
2,4-D amide	4	85	75
2,4-D amide	2	77	46
Amiben + 2,4-D amide	$2 + 1$	88	83
Amiben + 2,4-D amide	$1\frac{1}{2} + 1$	87	79
BASF-95 (N-chlorophenyl-N-methyl-N-isobutynyl urea)	6	96	91
BASF-95	3	81	78
Amiben + BASF-95	$2 + 2$	90	87
Amiben + BASF-95	$1 + 1$	75	53

*Liquid formula of amiben + atrazine in a 50:50 ratio.

Table 1. (cont.)

Tritac (2,3,6-trichloro- benzyloxypropanol)	6	94	91
Tritac	3	93	83
Tritac	$1\frac{1}{2}$	82	65
Amiben + Tritac	$1\frac{1}{2} + 1\frac{1}{2}$	87	77
Swep (methyl-3,4-dichloro- carbanilate)	4	96	93
Swep	2	73	47
Amiben + Swep	2 + 3	99	98
Amiben + Swep	1 + $1\frac{1}{2}$	93	83
Pyrazon [1-phenyl-4-amino-5- chloropyradazone-(6)7]	4	92	83
Pyrazon	2	67	47
Amiben + pyrazon	4 + 4	85	87
Amiben + pyrazon	2 + 2	72	77

Table 2. Control of annual weeds with several amiben mixtures applied post-emergence to corn.

Chemical	Rate lb/A	Percent weed control (Average of 3 replications)	
		Broadleaf	Grass
Dacthal + 2,4-D ester (butoxy ethanol)	8 + 2	93	90
Dacthal + 2,4-D ester	4 + 1	78	75
2,4-D ester	4	100	55
2,4-D ester	2	100	40
Bentrol (3,5-diiodo-4-hydroxy benzonitrile)	$\frac{1}{2}$	99	23
DNBP	1	98	23
DNBP + amiben	1 + $1\frac{1}{2}$	99	86
DNBP + amiben	$\frac{1}{2} + 3/4$	98	72
Amiben + Bentrol	$1\frac{1}{2} + \frac{1}{2}$	99	30
Amiben + Bentrol	$3/4 + \frac{1}{4}$	96	17

Up to 3 or 4 weeks after the pre-emergence treatments were made, the corn treated with 2,4-D amide or amiben-2,4-D amide combinations at 2 lb/A or more of 2,4-D amide showed growth abnormalities and suppression at the higher rates. Fenac appeared to reduce the stand at rates over 2 lb/A, but corn that did emerge appeared fairly normal. Growth suppression from fenac became apparent after about 5 or 6 weeks.

Seven to 8 weeks after treatment, weeds had suppressed corn growth more than any of the chemicals had. Some plants in the fenac and fenac-amiben plots down to 2 lb/A still showed some effect. For the first time an occasional plant was noted showing onion-leaf from 2,4-D ester down to 2 lb/A.

In one replication, the corn with 6 to 8 lb/A of pyrazon appeared to be turning slightly chlorotic. Although larger than corn in check plots, in some plots it appeared as if amiben was stunting corn growth at rates of 4 to 6 lb/A.

Post-emergence, DMBP alone and combined with amiben initially caused severe injury to corn over the entire logged distance. After about six weeks, the corn appeared normal though somewhat shorter. Bontrol caused much less burning than DMBP. 2,4-D ester caused some onion-leaf down to 2 lb/A but not below.

ADDITIONAL TESTS

Results from four pre-emergence corn trials in Minnesota, Iowa, and Nebraska conducted by Bush and Johnson¹ showed that combinations of amiben plus atrazine controlled annual weeds consistently in different soil types when moisture fell after application. Corn injury (early stunting or stand reduction) was apparent at one location in Iowa and one in Minnesota at the 6 lb/A rate of amiben. Yield data was not obtained from these experiments, but in the fall of 1963 there was no apparent corn injury from any treatment.

Pre- and post-emergence tests of amiben alone and in mixture with atrazine were applied to corn in Connecticut by Peters². Crabgrass was the principal weed. Amiben gave satisfactory control of weeds including crabgrass at the 2 and 4 pound rate. Although atrazine does not usually control crabgrass well, 2 lb/A pre-emergence was adequate in 1963, probably because of a favorable rainfall pattern. One or two pounds of amiben with 1 pound of atrazine gave good control of crabgrass equal to 2 pounds of atrazine alone. Two pounds of atrazine granular or 1 pound pre-emergence did not control crabgrass satisfactorily.

There was little difference in silage corn yields from the various plots. The only amiben treatment visibly affecting corn was the 12 lb/A rate. There was a yield of 12.6 tons per acre of 25% D. M. silage compared to 15.3 tons in the check.

To determine any remaining soil residues, a fall seeding of oats was made after the area was disced lightly. Only three treatments obviously decreased the oat stands: 2 lb/A of atrazine pre- and post- and 2 lb/A atrazine granular pre-emergence. Even where 12 lb/A of amiben had been used, the growth of oats was not affected.

¹Amchem Products, Inc., Agricultural Chemicals Div., Lincoln, Nebr. and Minneapolis, Minn., respectively.

²R. A. Peters, Dept. of Agronomy, Univ. of Conn., Storrs, Conn. Dr. Peters' cooperation in releasing this unpublished data is appreciated by the authors.

CONCLUSION

Of the mixtures tested by Hart, amiben at 1 lb/A plus atrazine at $1\frac{1}{2}$ lb/A and amiben at $1\frac{1}{2}$ lb/A plus Randox at 2 lb/A were the most promising treatments from the standpoint of weed control and crop safety. Neither of these mixtures was superior to 1 lb/A of atrazine alone.

For use where crabgrass is a problem, the mixture of 1 lb/A of amiben plus 1 lb/A of atrazine as in Peters' work appears equal to 2 lb/A of atrazine alone. In the same study, this mixture left less residue as measured by oat growth than 2 lb/A of atrazine alone.

Unpublished data from Minnesota, Iowa, and Nebraska indicates consistently satisfactory performance of amiben mixtures on a number of soil types.

From these preliminary tests, it would seem that where crabgrass is a problem or where soil residues present a hazard, amiben in mixture with Randox or atrazine should be investigated more thoroughly.

PRE- AND POST-EMERGENCE WEED CONTROL IN CORN - 1963

S. N. Fertig and A. H. Furrer^{1/}

The potential for increased yields of corn as silage or grain through better production practices is very great. On 50 percent of the corn acreage in New York, increases of 5 to 10 tons of silage or 25 to 50 bushels of shelled corn are possible. A significant part of the increase can be gained through better weed control.

The most competitive weed problems are quackgrass and annual grasses but as the annual broadleaved species have been reduced, the perennial broadleaves have increased. The perennial species predominant at present are: chicory, ground cherry, horse nettle, Canada thistle, field bindweed, hedge bindweed, perennial sow thistle, curled dock and milkweed.

With the wider use of compounds effective on annual broadleaved species, late germinating annual grasses are also increasing. The more prevalent species include: old witchgrass, crabgrass, barnyard grass, and green and yellow foxtail. Due to lack of favorable moisture at or within 2 to 3 weeks after treatment and time and rate of treatment, the triazines are not, in many cases, giving seasonal control of annual grasses. The increase can also be attributed to poorly timed cultivation, inadequate adjustment of cultivators or a complete lack of cultivation.

METHOD AND PROCEDURE

In 1963, four separate research trials were conducted on corn. These included pre-emergence, post-emergence and post-directional spray treatments. Experimental and recommended compounds were applied alone and in combination. The weed problem included annual broadleaves and grasses, perennial broadleaves and nutsedge.

A randomized block design was used in all experiments. The individual plots were 12 x 30 feet, with 6 - 30 inch rows of corn per plot.

Treatments were applied using a knapsack-CO₂ boom sprayer or an Allis Chalmers model-G tractor modified for plot spraying. All chemicals were applied in 30 gallons of water per acre.

The data collected included visual ratings for broadleaved and annual grass control, corn injury, and yields of grain corn. The yield values are based on the harvest from 3 rows per plot, using a picker-sheller combine.

The low yields of shelled corn are due in part to a killing frost on September 23.

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RESULTS AND DISCUSSION

Pre-emergence Treatments

The most effective and consistent weed control in the 1963 trials was obtained with pre-emergence applications. Not only was the control more effective but there was less corn injury and stand reduction.

Treatments showing good initial weed control carried through the season with insignificant changes in weed population. Any loss in effectiveness was reflected in an increase of annual grass species and in perennial broadleaved species.

For the pre-emergence treatments reported in Table 1, linuron at the 1 and 2 pound rate caused some initial stunting and chlorosis of corn. The injury, however, was not evident at the 1 pound rate in all replicates. The control of annual broadleaved and grass species was very good.

N-3446 at the higher rate was weak on annual broadleaves but very good on annual grasses.

Randox-T gave good initial annual broadleaved and grass control but did not hold the grass problem late in the season. This was a weakness with many compounds.

Eptam + 2,4-D, R-1910 + 2,4-D, and HS-119 showed fair to good control of annual broadleaves at the higher rates but were definitely weak on annual grasses. The higher rate of Eptam + 2,4-D caused some injury to corn. The higher rates of R-1910 + 2,4-D did not show injury to corn.

H-95-1 at the 2 and 3 pound rate gave good control of broadleaved and grass species. These rates, however, caused some chlorosis and stunting of corn, which was evident one month after treatment. There was no evidence of injury on these plots when observations were taken in early September.

Simazine gave very good to excellent weed control for the growing season.

For the treatments reported in Table 2, the amiben mixtures were not significantly better than the added compound alone at the same rate of chemical per acre. The combination would have an advantage if it controlled some weed species not affected by the added herbicide. Such evaluation was not possible on the weed species present in these treatments.

Amiben at rates up to 3 pounds was weak on annual broadleaves and on annual grasses. The degree of effectiveness was about the same on both groups. There was some corn injury at the 4 pound rate of application but weed control was good.

Randox-T applied pre-emergence + atrazine applied post-emergence gave good control of annual broadleaved and only fair control of annual grass

species. There was no advantage to the mixture over either chemical alone when used pre-emergence at the same rate per acre.

Mixtures of herbicides applied in combination or as split applications pre- and post-emergence may offer the opportunity for the control of a broader spectrum of weed species and at the same time, permit the use of lower rates of the more persistent compounds with their associated residual problems. Evaluation on a broader weed spectrum, timing of application and possible synergistic effects need further evaluation.

Post-emergence Treatments

The post-emergence treatments summarized in Table 3 were less effective on all weed species when compared to pre-emergence or post-directional treatments. With the exception of linuron at the rate of 2 pounds per acre, they were all weak on the seasonal control of annual grasses. The addition of the surfactant to linuron increased the initial injury to corn with no marked increase in annual broadleaved control. The annual grass control was 15 to 25 percent higher with the surfactant treatment. The linuron and prometryne, without surfactant, gave severe burning on corn. This was not reflected in corn height or stand when the final control ratings were taken on September 12.

Alipur + O-DN and Alipur + CIPC mixtures were weak on all species. Some initial injury to the corn leaves was evident.

The oil-soluble amine of 2,4-D gave fair broadleaved control at the 1/2 pound rate and good control at the 3/4 pound. The broadleaved control has been about equal to that with water-soluble amine but less effective when compared with the same rate of 2,4-D ester formulations.

The variability of control with post-emergence application of herbicides continued to widen in 1963. Growers are not conscious of the timing factor and delay treatment too long. Early weed competition has taken some toll of yield and the weed species are more difficult to kill. It seems desirable to place stronger emphasis on applications applied at or near corn emergence.

Post-directional Spray Treatments

Several of the chemicals applied as post-directional sprays gave fair to very good control of annual broadleaved and annual grass species. Both linuron and prometryne, with and without surfactant, caused burning of the corn leaves where they were contacted with the spray. The treatments with the surfactant exhibited more serious initial injury which affected the early growth of the corn. Linuron with the surfactant definitely thinned the stand of corn; up to 40 percent reduction in some replicates. Also, there is some evidence that linuron may have contributed to a reduction in stalk diameter. The addition of surfactant to these two compounds increased their effectiveness on the annual grass species but did not show any advantage for the control of the broadleaved species.

Based on the effectiveness of weed control, the post-directional treatment may be useful to cover emergency situations, where earlier treatments are not

Table 1
PRE-EMERGENCE WEED CONTROL IN CORN - 1963

Treat. No.	Chemical	Rate/A lbs. a.i.	Average rating for 4 replications for annual broadleaved and annual grass control*				Yield shell 'corn. Bu/A 'at 15% H ₂ O	Ave. # Corn plants/30 ft. row**
			July 12, 1963		Sept. 12, 1963			
			Bl. weeds	Ann. Gr.	Bl. weeds	Ann. Gr.		
1	Linuron	1	9	8	8	8	38.2	38
2	Linuron	2	9+	9+	9+	9	40.2	38
3	N-3446	4	1	4	1	8+	27.8	41
4	N-3446	6	3	8+	3+	9	36.8	38
5	Atrazine, wp	1	9+	9+	10	9+	43.4	41
6	Atrazine, wp	2	10	9+	10	9+	46.2	42
7	Atrazine, 10G	1	9+	8+	9+	7+	41.6	41
8	Linuron, post-directional	3/4	-	-	8+	2	24.2	40
9	Linuron, post-directional	1	-	-	9	4	28.8	40
10	Atrazine, wp. Overall- after 1 cultivation	1	-	-	5+	3+	41.5	42
11	Randox-T	4	8+	6+	8+	5+	42.1	41
12	Randox-T	6	9	8+	8+	6+	39.2	40
13	Dacamine 4-D	1	4	2	6+	0	26.9	39
14	Dacamine 4-D	1.5	8	3	7	1+	29.8	39
15	2,4-D, LVE	1	4	2	5+	1	30.4	39
16	2,4-D, LVE	1.5	7+	5	7+	1+	34.4	38
17	Eptam + 2,4-D, LVE	2 + 1	3	1	5	2	32.3	39
18	Eptam + 2,4-D, LVE	4 + 2	8+	6	7+	4	39.2	39
19	R-1910 + 2,4-D	2 + 1/2	6	3	5+	1+	27.7	41
20	R-1910 + 2,4-D	4 + 1	6+	3	7	3	31.6	38
21	H-95-1	1.5	7	8	8	4+	39.1	40
22	H-95-1	2.0	9	9+	8+	6+	44.0	40
23	H-95-1	3.0	9+	8	9+	8+	40.0	39
24	HS-119	2.0	5	1+	5+	1	30.5	40
25	HS-119	3.0	8+	2	8+	3	38.5	40
26	Simazine, wp	2.0	10	9+	9+	9+	44.6	39
27	Cultivated check, 2 times	---	-	-	5	4+	29.7	39
28	Cultivated check, 3 times	---	-	-	5+	6	28.0	38
29	Check, no cultivations	---	-	-	-	-	10.0	39

* 0 = no control. 10 = complete control.

** Value represents the average number of corn plants at harvest, based on stand count of the 3 harvest rows in each replicate.

Table 2
PRE-EMERGENCE TREATMENTS ON CORN - 1963

Treat. No.	Chemical	Rate/A lbs. a.i.	Average rating for 4 replications for annual broadleaved and annual grass control*							
			July 13, 1963		Sept. 7, 1963		Yield shell corn. Bu/A at 15% H ₂ O	Ave. # Corn plants/30 ft. row**		
			Bl. weeds	Ann. Gr.	Bl. weeds	Ann. Gr.				
1	Amiben + Atrazine	1.0 + 1.0	9++	9	9	8+	41.2	38		
2	Amiben + Atrazine	1.5 + 1.5	9++	9++	9++	9++	59.4	41		
3	Amiben + Atrazine	2.0 + 1.0	9++	10	9++	9++	57.9	39		
4	Amiben + Linuron	1.5 + 1.5	9+	9	9	7+	52.9	40		
5	Amiben + Linuron	1.0 + 1.0	9	9	8+	8	45.7	39		
6	Amiben + Prometryne, 150-E	1.5 + 1.5	9	9+	9	8+	41.9	39		
7	Amiben + Prometryne, 150-E	2.0 + 2.0	9	9	9	8+	43.2	39		
8	Amiben + Fenac	1.5 + 0.5	4	6	7	4	37.1	39		
9	Amiben + Emdid	2.0 + 0.5	6	7	7	6+	46.8	39		
10	Amiben	2.0	5	6	4++	5+	44.0	41		
11	Amiben	3.0	6	8	5++	6++	36.8	39		
12	Amiben	4.0	8	9	8	7	50.5	41		
13	Atrazine, wp	1.0	9++	9++	9++	9	46.8	41		
14	Atrazine, wp	2.0	9++	9++	10	9++	58.7	40		
15	Linuron + WA	1.0	8+	9	8+	7+	54.5	40		
16	Linuron + WA	2.0	10	9++	9++	9+	44.8	40		
17	Prometryne + WA	1.0	9+	9++	7++	7++	54.3	40		
18	Prometryne + WA	2.0	9	9	8++	9++	47.5	40		
19	Radox-T	3.0	6	6	8	6	51.9	39		
	Atrazine	1.0								
20	Amiben +	1.5	10	10	9+	9	51.8	39		
	Atrazine	1.0								
21	Amiben +	1.0	10	10	10	9+	43.3	39		
	H-95-1	1.5								
22	Linuron +	1.0	9++	9+	9	8+	54.3	38		
	Atrazine	1.0								
23	Cultivated	2 times	---	---	5+	5	46.4	39		
24	Cultivated	3 times	---	---	5++	5++	40.6	40		
25	Check	No cultivations	---	---	---	---	23.3	38		

* 0 = no control. 10 = complete control

** Value represents the average number of corn plants at harvest, based on stand count of the 3 harvest rows in each replicate.

Table 3
POST-EMERGENCE WEED CONTROL IN CORN - 1963

Treat. No.	Chemical	Rate/A lbs. a.i.	Average weed control rating of 4 replications for annual broadleaved and annual grass control*							
			July 12, 1963		Sept. 12, 1963		Yield shell corn. Bu/A at 15% H ₂ O	Ave. # Corn plants/30 Ft. row**		
			Bl. weeds	Ann. Gr.	Bl. weeds	Ann. Gr.				
1	Prometryne, 150-E	1.0	8	6	5+	3	37.4	40		
2	Prometryne, 150-E	2.0	8+	8	8	5	35.8	40		
3	Linuron	1.0	9+	6	9+	4	37.3	41		
4	Linuron	2.0	9++	9	9++	7++	44.7	39		
5	Linuron + WA	1.0	9+	8+	9+	6+	41.5	41		
6	Linuron + WA	2.0	9++	9+	9++	9	44.3	41		
7	Linuron + WA Post-directional corn 10-12" tall.	1.0	-	-	9+	6+	27.1	39		
8	Linuron + WA Post-directional corn 10-12" tall.	2.0	-	-	9++	7+	31.8	35		
9	Atrazine, wp	1.0	8	5	9	1+	40.2	40		
10	Atrazine, wp	2.0	9	3	9+	2+	37.9	41		
11	ACP 62-177A + Amiben	1/4 + 2.0	7	2	8+	1	32.9	39		
12	ACP 62-177A + Amiben	1/4 + 3.0	7	2	7	1	34.3	43		
13	ACP 62-177A + Amiben	1/2 + 2.0	8+	2	8++	1	24.0	42		
14	Atrazine + Linuron	1.0 + 1.0	9+	8+	9++	6	50.6	40		
15	Atrazine + Linuron	1/2 + 1.0	9+	9	9++	4++	44.7	38		
16	Atrazine + 2,4-D amine	1.0 + 1/2	9+	2	9++	1	26.6	40		
17	H-95-1	1.5	2	0	1	0	39.4	38		
18	H-95-1	2.0	2	0	2	0	30.6	39		
19	H-95-1	3.0	2	0	2	0	14.2	40		
20	Alipur + 0-DN	1.0	7	3	4++	1	33.5	41		
21	Alipur + 0-DN	2.0	6+	2+	2	0	25.8	41		
22	Alipur + CIPC	1.0	2	0	3+	1	34.5	42		
23	Alipur + CIPC	2.0	2	4	3	2	22.7	40		
24	Dacamine 4-D	1/2	6+	1	8+	0	21.9	40		
25	Dacamine 4-D	3/4	9	2	9+	0	42.8	39		
26	Atrazine + Cultivation	1.0 + 2	9	6	9+	6+	48.3	40		
27	Linuron + Cultivation	1.0 + 2	9+	9+	9++	8	50.3	40		
28	Cultivated, 2 times	---	-	-	5	5	41.2	40		
29	Check, no cultivations	---	-	-	-	-	9.1	41		

* Rating Scale - 0 no control. 10 complete control.

** Value represents the average number of corn plants at harvest, based on stand count of the 3 harvest rows in each replicate.

Table 4
POST-DIRECTIONAL SPRAY TREATMENTS ON CORN

Treat. No.	Chemical	Rate/A lbs. a.i.	Average control rating of 4 replications for annual broadleaved and annual grass* September 7, 1963		Yield shell corn. Bu/A at 15% H ₂ O	Ave. # Corn plants/30 ft. row*****
			Broadleaved weeds	Annual grasses		
1	Linuron**	1.5	9	6+	36.2	43
2	Linuron	2.0	9+	8++	51.2	41
3	Linuron + surfactant	1.5	9+	9	41.8	36
4	Linuron + surfactant	2.0	9+	9	29.7	33
5	Prometryne + surfactant	1.5	9	7+	38.8	38
6	Prometryne + surfactant	2.0	9	8++	26.3	37
7	Prometryne, 150-E	1.5	8++	6	35.7	39
8	Prometryne, 150-E	2.0	9+	6++	30.7	37
9	Atrazine, wp.***	1.5	9++	9++	60.3	40
10	Atrazine, wp.	2.0	9++	9++	62.4	40
11	Atrazine, wp.****	1.5	8+	4	49.2	41
12	Atrazine, wp.	2.0	9+	6	53.2	42
13	H-95-1	1.5	1	1	25.6	40
14	H-95-1	2.0	1+	1+	38.3	40
15	Linuron + 2,4-D amine	1.5 + 0.5	9+	8	49.1	39
16	Atrazine + 2,4-D amine	1.5 + 0.5	9+	4+	49.8	41
17	Atrazine, wp.	1.0	7++	4+	55.8	41
18	Atrazine, wp.	2.0	9	6	49.6	42
19	Check	0.0	0	0	21.1	41

* 10 = complete weed control. 0 = no control. Ratings do not consider corn injury or stand reduction.
** Treatments 1 through 8 and 13 through 18 applied post-directional when corn averaged about 10 inches tall.

*** Treatments 9 and 10 applied as pre-emergence overall sprays, 5 days after planting.

**** Treatments 11 and 12 applied as post-emergence overall sprays, corn 5 to 6 inches tall.

***** Value represents the average number of corn plants at harvest, based on stand count of the 3 harvest rows in each replicate.

applied or are ineffective. Proper nozzle adjustment in relation to the height of corn and weeds is essential to minimize initial injury.

The post-emergence treatments of atrazine were weak on annual grasses. The predominant species not controlled was old witchgrass (Panicum capillare). The other species remaining were yellow foxtail, green foxtail, ground cherry, hairy spurge, yellow wood sorrel, ladythumb and some ragweed.

The average weed control ratings and yields of shelled corn are reported in Table 4.

Evaluation of Herbicides for Annual Grass Control in Corn

R. A. Peters and P. E. Keeley^{1/}

Introduction

While atrazine is generally employed for weed control in corn in Connecticut, two disadvantages are associated with its continued use. Crabgrass, particularly, small crabgrass, (*Digitaria ischaemum*) has been shown to be more resistant (Peters and Keeley, (1963)^{2/} to either pre- or post-emergence applications of atrazine than most annual weeds associated with corn. An ecological shift is appearing in fields treated for several successive years with atrazine since crabgrass develops essentially free of competition.

Prolific growth is resulting in a heavy seed accumulation which will result in a continuing problem in corn and in succeeding crops such as forage seedings. As in other areas, there is concern in Connecticut about residue carry-overs of atrazine resulting in injury to succeeding crops such as oats or legume seedings. The experiment discussed below was designed to evaluate several herbicides and mixtures of herbicides for corn weed control which would 1) give better crabgrass control and 2) result in less of a residual problem than does atrazine.

Materials and Methods

The experiment was carried out on the Agronomy Research Farm of the Storrs (Conn.) Agricultural Experiment Station. The plots were on a Paxton fine sandy loam fertilized with 1000 lbs. of 15-10-10 per acre. Pa. 602A corn was planted on May 31, 1963 in 10 by 18 feet plots. A randomized block experimental design replicated three times was employed.

Grassy weeds predominated on the plots. In order of prevalence was crabgrass (*Digitaria* spp.), old witch grass (*Panicum capillare*), yellow foxtail (*Setaria lutescens*) and barnyard grass (*Echinochloa crusgalli*). Broadleaf weeds present included ragweed (*Ambrosia artemisiifolia*) and rough pigweed (*Amaranthus retroflexus*). The chemicals and rates used in the experiment are given in Table 1.

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^{2/} Peters, R. A. and Keeley, P. E. The crabgrass problem associated with the use of atrazine. Proceedings of the Northeastern Weed Control Conference. 17: 343-347. 1963.

Table 1. Weed control, silage corn yields, and subsequent oat growth following treatment with several herbicides.

Chemical Treatment ^{1/} (lb. a.i. or a.e. per A.)	Grassy weed		Broadleaf weed		Silage corn yield Ton/A. ^{3/}	Oat stand density 11/18	
	<u>control</u> 7/22	<u>ratings</u> ^{2/} 9/24	<u>control</u> 7/22	<u>ratings</u> ^{2/} 9/24			
Check		8.0	3.1	5.3	3.5	15.5	8.3
Atrazine 1		3.0	6.0	0.0	0.3	15.3	7.3
Atrazine, incorporated	1	1.3	1.0	0.3	0.0	15.9	8.0
Atrazine 2		0.7	1.0	0.0	0.0	17.0	8.0
Atrazine, granular	2	3.0	6.3	0.0	0.0	15.2	3.0
Atrazine 2		3.7	3.0	0.0	0.0	16.5	2.0
Post-emergence, directed							
Atrazine 1		1.3	1.7	0.0	0.0	16.4	8.7
+							
Simazine 1							
Prometryne 2		0.7	1.0	0.1	0.0	16.4	9.0
Amiben 1		2.3	3.3	1.3	1.3	14.8	9.7
Amiben 2		1.9	1.7	2.0	1.3	14.9	9.3
Amiben 4		0.3	0.6	0.3	0.0	15.5	9.3
Amiben 12		0.0	0.0	0.0	0.0	12.6	9.0
Amiben 1		1.0	1.6	0.0	0.0	17.1	9.0
+							
Atrazine 1							
Amiben 2		1.0	0.3	0.3	0.0	16.3	10
+							
Atrazine 1							
Linuron 1		1.0	1.0	0.0	0.0	16.7	9.7
EPTC							
+							
2,4-D 2		1.0	1.0	0.0	0.0	17.2	9.3
EPTC 2		1.3	0.6	0.7	0.3	17.6	8.3
+							
2,4-D incorporated							
Dichlobenil 3		3.3	3.0	2.3	1.0	16.3	8.0
Dichlobenil 6		1.7	1.5	0.0	0.3	15.7	6.0
2,4-D, ester	2	1.3	0.6	0.7	0.0	16.6	8.7
Linuron 2		0.7	0.3	1.0	0.0	17.5	8.3
directed post- emergence							
Paraquat 2		0.0	0.0	0.0	0.3	17.1	9.7

^{1/}All chemicals applied as pre-emergence sprays unless indicated.

^{2/}Rating on 0-10 scale. 0-10 scale. 0-no stand, 10-complete cover.

^{3/}On basis of 25% D.H.

All pre-emergence treatments were applied with a bicycle type compressed air sprayer with 40 gallons per acre of solution used for each treatment. Post-emergence applications were directed sprays applied with a knapsack sprayer. Pre-emergence applications were made on June 6, 1963. The soil surface was dry, but soil moisture was adequate. Post-emergence applications were made on July 10, 1963 when the corn was 2 feet tall and the weeds averaged 6-8 inches.

Rainfall for the growing season was below normal with 2.8, 2.7, 1.7 and 3.8 in. in June, July, August and September respectively. The corn, however, showed little indication of moisture stress since rainfall was favorably distributed. The rainfall pattern following the pre-emergence applications favored the activity of surface applied chemicals since .43 in. and .40 in. fell 4 days and 6 days, respectively, after treatment.

Weed control was judged by making periodic stand density ratings on a 0-10 scale. Silage corn yields were obtained by sampling the center two rows from each plot. While oven dry yields were obtained, the yields are reported on a 25 per cent dry matter basis.

Results and Discussion

Weed Control

Control of both the grassy and broadleaf weeds was satisfactory from most of the treatments. The rainfall pattern favored penetration into the weed seed zone but no further until after germination had occurred. Under these conditions 2,4-D ester controlled both grassy and broadleaf weeds as satisfactorily as the 2 lb. atrazine treatment. The satisfactory crabgrass control from 2 lb. atrazine, in contrast to many instances of poor control, can be associated with a rainfall pattern which concentrated the herbicide in the seed germinating zone.

The treatments giving unsatisfactory control of crabgrass were atrazine 1 lb. pre-emergence, atrazine 2 lb. granular pre-emergence, atrazine 2 lb. post-emergence, amiben 2 lb. and dichlobenil 3 lb. The predominant species remaining in the plots was small crabgrass, (*D. ischaemum*). This is in line with an earlier report by Peters and Kesley that this species is more resistant to atrazine than is large crabgrass, (*D. sanguinalis*).

The triazine treatments which did control crabgrass were atrazine 2 lb. pre-emergence, atrazine 1 lb. pre-emergence lightly incorporated into the soil surface 18 days after treatment, prometryne 2 lb. pre-emergence and the combination of simzaine 1 lb. and atrazine 1 lb. pre-emergence. The mixture of the two triazines was no more effective in controlling crabgrass than 2 lb. of atrazine alone. This was in contrast to other work indicating an advantage for the mixture.

Poor broadleaf weed control occurred when atrazine 1 lb. pre-emergence or atrazine 2 lb. granular pre-emergence were used. Only fair broadleaf control was obtained from atrazine 2 lb. post-emergence, amiben 1 lb. and dichlobenil 3 lb.

Grass stands were actually lower in the check than in the plots treated with atrazine 1 lb. w.p. or 2 lb. granular with stand density ratings of 3.1, 6 and 6.3 respectively. (Table 1). The lower stand in the check can be attributed to

As indicated by Table 1, silage corn yields varied very little from one treatment to another. The one treatment which did decrease yields was amiben at 12 lb. per acre. The decrease was from 15.5 to 12.6 tons per acre. Injury from this treatment was evident when notes were taken at the 2 foot height. Between 10-20 per cent of the plants displayed onion rolling and some stunting. The stand was not reduced but the stunting prevailed throughout the growing season.

Approximately 10 per cent of the corn plants treated with EPTC displayed onion rolling but there was no permanent effect.

Paraquat applied as a directed spray caused serious contact injury to any corn leaf which it contacted. One to two plants developed over-all chlorosis followed by death but the other plants were not effected except for the loss of the lower leaves directly hit by the paraquat. This material was very active on all of the weed species present causing a complete kill within less than a week after application.

Residue Determination

As judged by stand density ratings of the oats on November 18, 52 days after seeding, there was relatively little carry-over despite the dryer than usual season. Atrazine 2 lb. post-emergence or granular pre-emergence did cause serious injury with a rating of 3 and 2 respectively as compared to 8.3 for the check. Some residual activity was also found from dichlobenil at the 6 lb. rate with a rating of 6.

Despite less than normal rainfall during the experiment, the results tie in with other observations made in southern New England and suggest that in the soil climatic-complex found in Connecticut the recommended atrazine treatment of 2 lb. a.i. wettable powder does not pose a residue problem on field crops following in sequence. Some vegetable crops are less tolerant and since mis-application is always a possibility, there is a need for a corn herbicide which is less marginal than atrazine.

Summary

In this experiment better control of small crabgrass with atrazine 2 lb. per A. w.p., and of all annual grasses present with 2,4-D, was obtained than is usually the case. This was attributed to the favorable rainfall pattern. While atrazine at 1 lb. pre-emergence did not give satisfactory grass control, it was satisfactory if incorporated 18 days after application. The atrazine 2 lb. granular pre-emergence and wettable powder post-emergence applications were not effective on crabgrass.

Other pre-emergence treatments which gave very good grass control included amiben 4 lb., EPTC + 2,4-D 2 lb., and prometryne 2 lb. pre-emergence. Linuron 2 lb. and paraquat 2 lb. gave good control applied as directed post-emergence treatments.

The only treatment causing obvious growth and yield reduction in corn was amiben 12 lb.

As measured by an oat bioassay crop planted as soon as the corn was harvested, residues were evident only from atrazine 2 lb. post-emergence or granular pre-emergence from dichlobenil at 6 lb.

CHEMICAL CONTROL OF ANNUAL MORNING GLORY IN SOYBEANS¹

by

H. P. Wilson and R. H. Cole²

A major problem encountered in commercial soybean production in Delaware is the control of annual morning glories, *Ipomoea purpurea* L. and *Ipomoea hederacea* L. They not only compete for moisture and nutrients, possibly reducing yield, but they tend to grow up the soybeans, wrapping around the plants as they grow. This causes severe lodging and makes harvest difficult. Since morning glories have been observed to germinate throughout most of the growing season, a long-lasting selective herbicide is required for their control. A study was undertaken in 1963 to determine if there were any chemicals of this type presently available.

Procedure

This study was carried out at the University Substation Division Farm, Georgetown, on a Norfolk sandy loam and at the University Farm, Newark on a Matapeake silt loam. The land was prepared in the conventional manner and the treatments described in table 1 were applied. Clark soybeans were planted on June 7 in Georgetown and Bethel soybeans were planted in Newark on June 13. The pre-plant and pre-emergence treatments were made on the day of planting and the post-emergence applications were made at the first true-leaf stage of the soybeans which occurred about 10 days after planting. Soybeans were rated for herbicidal injury about 3 weeks after planting and again at harvest time. Also recorded at harvest were percent stand of soybeans and percent morning glory control.

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 2. Research Fellow and Assistant Professor of Agronomy, University of Delaware, Newark, Delaware.

Results and Discussion

Table 2 shows the results obtained at both locations. Where the same relative results at Newark and Georgetown were evidenced, the locations were combined and only one average is given.

Stauffer R 1607 looked better than the other herbicides tested. It controlled morning glory effectively when incorporated to a depth of 4 inches as a pre-plant treatment or to a depth of 1/2 inch following planting. However, higher yields were obtained when it was applied as a post-emergence treatment. This could result from less soybean injury being incurred by the latter treatment.

Trifluralin was also effective in controlling morning glory but reduced soybean stands when it was deeply incorporated. All plots treated with this material produced lower yields of soybeans. When Prometryne was incorporated stand reduction occurred but when applied as a surface treatment, visible injury was not evidenced. Both treatments greatly reduced morning glory populations but soybean yields were also decreased.

One chemical, SD 7961, was highly injurious to the soybeans and ineffective in its control of morning glory.

Summary

The possibility of using chemicals presently available to obtain full season control of annual morning glory was investigated. Of the four chemicals tested all but one, SD 7961, gave effective control of these weeds. The most promising herbicide tested was Stauffer R 1607. Two other herbicides, trifluralin and Prometryne, reduced stands of soybeans when deeply incorporated and reduced yields in all methods of application at which they were tested. The results indicate, however, that future testing for morning glory control of R 1607, trifluralin and Prometryne would be worthwhile.

Acknowledgements

The authors wish to acknowledge the assistance of the herbicide manufacturers in making available the materials used in these tests and thank them for their continued

Table 1. Herbicide Treatments Applied in 1963.

<u>Herbicide</u>	<u>Rate (Lbs/Acre)</u>	<u>Formulation</u>	<u>Methods of Application</u>
R 1607 ¹	4	Granular	Pre-plant incorporated
Trifluralin ²	2	Liquid	Pre-plant incorporated
Prometryne ³	2	Liquid	Pre-plant incorporated
R 1607	4	Granular	Surface-inc. by rake
Trifluralin	2	Liquid	Surface-inc. by rake
SD 7961 ⁴	2	Granular	Surface-inc. by rake
Prometryne	2	Liquid	Surface spray
R 1607	4	Granular	Post-emergence rotary hoed in
SD 7961	2	Granular	Post-emergence rotary hoed in
Check	-----	-----	Cultivated

1. n-propyl di-n-propylthiolcarbamate
2. 2,6-dinitro-N, N-di-n-propyl-a, a, a-trifluoro-p-toluidine
3. 2,4-bis (isopropylamino)-6-methylmercapto-s-triazine
4. 2,6-dichlorothiobenzamide

Table II. Injury Ratings, Percent Stand, Percent Morning Glory Control and Yields Obtained in 1963 Tests.

	SOYBEAN INJURY ¹				Percent Stand, Locations Combined	Morning Glory Control, Locations Combined	Yield ² Bushels/Ac Locations Combined	
	3 Week Rating		At Harvest					
	Newark	Georgetown	Newark	Georgetown				
1	R 1607 granular pre-plant inc.	4.5	2.0	2.2	1.0	98	92	19.3 AB
2	Trifluralin liquid pre-plant inc.	5.0	2.5	4.0	1.2	82	94	14.6 C
3	Prometryne liquid pre-plant inc.	3.2	2.5	1.0	1.2	90	84	17.8 BC
4	R 1607 granular inc. by rake	2.5	2.0	1.0	1.0	100	94	19.0 A
5	Trifluralin liquid inc. by rake	2.0	1.0	1.2	1.0	100	88	16.6 BC
6	SD 7961 granular inc. by rake	5.0	5.0	5.0	4.0	38	25	10.0 D
7	Prometryne liquid surface spray	1.0	1.0	1.0	1.0	100	80	17.5 BC
8	R 1607 granular post-emergence	2.2	1.0	1.0	1.0	100	84	23.0 A
9	SD 7961 granular post-emergence	2.5	5.0	5.0	4.0	28	25	8.3 D
10	Check(cultivated)	1.0	1.0	1.0	1.0	100	0	21.5 A

1. Scale: 1 = No crop injury 3 = Severe stunting 5 = Killing
 2 = Slight stunting 4 = Very severe stunting

2. Any two means followed by the same letter are not significantly different.

PERFORMANCE OF SEVERAL PROMISING SOYBEAN
HERBICIDES,

1961 - 1963¹

R. H. Cole, R. S. Boyce and E. L. Wisk²

One of the major factors limiting soybean yields is weeds. The herbicides presently used have not been consistently effective against a wide spectrum of weed species. Better chemicals and a greater knowledge about the use of these materials are urgently needed. This is a report of the performance of eight of the more promising soybean herbicides tested in the state of Delaware in 1961, 1962, and 1963. Suggestions for future investigations are included.

Procedure

Soybean weed control tests were conducted in 1961, 1962, and 1963 at the University Substation, Georgetown, Delaware on a Norfolk sandy loam. The herbicides used and the methods of application are listed in table 1. A recommended soybean variety was planted the last week in May in a prepared seedbed using a thirty-six inch row spacing. All materials were applied as sprays. Light rainfall, sufficient for the activation of herbicides and for rapid germination of soybeans and weeds, was obtained in 1961 and 1962. A heavy rain (2.85 inches) followed treatment in 1963.

The predominating weeds present in the test plots were pigweed (Amaranthus retroflexus), ragweed (Ambrosia artemisiifolia), foxtail species (Setaria sp.), common

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 2. Assistant Professor of Agronomy, and Research Associates of the University Substation Division, University of Delaware, Newark, Delaware. Mr. R. S. Boyce is presently employed by the United States Army.

crabgrass (*Digitaria sanguinalis*) and goose grass (*Eleusine indica*).

The weed control and crop injury ratings reported in this paper were visual estimates recorded approximately three weeks following planting.

Results and Discussion

The summary of the weed control data for 1961-1963 (table 2) indicates that several of the herbicides tested in Delaware from 1961 through 1963 provided effective early weed control. The crop injury obtained by the use of some of the more effective herbicides, however, might limit their acceptability for field use at the rates tested (table 3). Differences in weed control and soybean injury ratings among seasons, a measure of the consistency of a herbicide, were attributed to the amount of rainfall obtained after the herbicides were applied.

The lowest crop injury ratings were evidenced with linuron and sodium pentachlorophenate, although other herbicides have been superior in their weed control ratings. The most effective weed control over the past two years has been obtained with Prometryne, Stauffer R 1607 and trifluralin. The latter two have shown the greatest over-all promise. The amount of crop injury and the rates used of these chemicals should be major considerations in future methods of application tests. Placement of these chemicals in close proximity to the soybean seed can significantly reduce early seedling vigor. It is suggested that selectivity studies of lower rates of Amiben, diphenamid and Prometryne should be conducted to establish their desirability in future soybean herbicide mixtures.

Summary

The weed control capabilities and limitations and crop injury ratings of eight promising soybean herbicides have been discussed. Considerations in future investigations of these materials have been proposed.

Acknowledgements

The authors wish to acknowledge the assistance of the herbicide manufacturers in making available the materials used in these tests and thank them for their continued interest

Table 1. Rates and Methods of Application of the Herbicides Tested.

<u>Herbicide</u>	<u>Rate a.i. lbs./A.</u>	<u>Method of Application</u>
DNBP	4 1/2	Pre-emergence within 24 hours of planting
Amiben	3	"
NaPCP	20	"
Diphenamid	4	"
Prometryne	2	"
Linuron	1	"
Stauffer R 1607	4	Pre-plant followed by rototiller and planter
Trifluralin	2	"

Table 2. Weed Control Ratings of the Eight Herbicides Tested.

<u>Herbicide</u>	<u>Broadleaf Rating</u>			<u>Grass Rating</u>		
	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
DNBP	Fair	Good	Poor	Poor	Fair	V. Poor
Amiben	Good	Good	Poor	Good	Good	Poor
NaPCP	Good	Good	Fair	Poor	Fair	Poor
Diphenamid	Good	Good	Good	Good	Good	Good
Prometryne	Excel.	Good	Good	Excel.	Good	Good
Linuron	-----	Good	Good	----	Good	Fair
Stauffer R1607	-----	Good	Good	----	Good	Excel.
Trifluralin	-----	Good	Good	----	Excel.	Excel.

Table 3. Crop Injury Ratings of the Eight Herbicides Tested.

<u>Herbicide</u>	<u>Ave. Crop Injury Rating¹</u>		<u>No of Years above 2.0¹</u>	<u>No. of Years Tested</u>
	<u>1962 1963</u>	<u>1961, 1962 1963</u>		
DNEP	1.5	1.8	1	3
Amiben	2.2	2.3	2	3
NaPCP	1.0	1.2	0	3
Diphenamid	2.5	2.7	3	3
Prometryne	2.8	2.8	3	3
Linuron	1.0		0	2
Stauffer R1607	2.2		1	2
Trifluralin	2.2		1	2

1. Crop Injury Rating: 1 = No injury, stand 100%
 2 = Slight stunting, stand 100%; and 3 = severe
 stunting, stand may be reduced slightly.

PRELIMINARY OBSERVATIONS ON
WEED CONTROL IN SUGAR BEETS

S. N. Fertig^{1/} and R. L. Zimdahl^{2/}

In early 1962 several farmers and businessmen became interested in investigating the potential of sugar beets as a cash crop for central New York State. The Agronomy Department at Cornell and the Cayuga County Extension Service carried out small scale studies in 1962. These indicated that weed control would be a major problem in sugar beet production. In 1963 research plots were established to further investigate the problem and alternative solutions.

Methods and Procedure

Two weed control research plots were established in 1963. The first (location I), on a Honeoye silt loam in Southern Cayuga County, had 34 different overall treatments which included 13 compounds or combinations and two cultural treatments. The second (location II) was in Central Cayuga County on a Lima silt loam. It had 21 treatments including 9 compounds all of which were applied in an 8" band.

Some of the treatments at location II were applied with a 4-row planter at planting. All others at both locations, were applied with either a CO₂ hand sprayer or an A-C rear engine tractor, with an 8' boom.

Both plots were planted on April 18th with the variety SL 122 MS x 5460-0 and a uniform fertilizer rate of 800# of 10-20-20 plus 1/4% boron per acre. The initial plot fertility was:

Location	pH	P	K	OM	B
I	7.1	6	115	3.0	1.8
II	5.8	8	80	3.5	3.6

The weed problem was essentially the same at both locations but the weeds at location I were more numerous and vigorous throughout the season. The three most prevalent weeds were: lambsquarters, ragweed, and quackgrass. The weed problem is complicated not only by the problem of lambsquarters and its close relationship to beets, but also by the presence of many annual and perennial grasses. In addition to those above the following weeds were problems: mustard, black medic, field bindweed, pigweed, smartweed, summer foxtail, and barnyard grass. There were also at least ten other species present to a lesser degree. Early in the season quackgrass became so serious a threat to the survival of the beets and value of the work at location I that it was pulled by hand over the entire plot.

Seasonal Observations

The plots were observed periodically throughout the season for evidence of control of weeds and injury to the beets. There was no evidence of injury to the beets after the middle of June. Location II showed slight stunting from treatment 13 (TCA + Endothal 9.375 + 5.625#). However, at location I a range of injury was observed. Treatments 9-16, 28, 30 either killed all of

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Table 1
Summary of Treatments
Weed Control Research, 1963
Location I

Treat. No.	Herbicides	Rate/A. lbs. A.I.	Time of Application		
			Inc.	Pre-	Post-
1	Pyramin	2.5		x	
2	Pyramin	3.5		x	
3	HS-119-1	2.5			x
4	HS-119-1	3.5			x
5	CP-32179	2.0		x	
6	CP-32179	4.0		x	
7	CP-22819 + Avadex	2.0 + 1.0	x*		
8	CP-22819 + Avadex	2.66 + 1.33	x*		
9	G-36393 (25E)	1.0		x	
10	G-36393 (25E)	2.5		x	
11	G-36393 (25W)	1.0		x	
12	G-36393 (25W)	2.5		x	
13	G-36393 (25W) + CIPC	1.0 + 6.0		x	
14	G-36393 (25W) + CIPC	2.0 + 4.0		x	
15	Prometryne (L)	1.0		x	
16	Prometryne (L)	2.0		x	
17	TD-291	3.5		x	
18	TD-291	4.5		x	
19	TCA + Endothal	9.375 + 5.625		x	
20	TCA + Endothal	6.875 + 4.125		x	
21	TCA + Endothal	8.0 + 2.0		x	
22	Endothal + Dalapon	2.0 + 2.0			x
23	Endothal + Dalapon	2.0 + 3.0			x
24	Tillam	4.0	x*		
25	Tillam	6.0	x*		
26	Tillam	4.0	x**		
27	Tillam	6.0	x**		
28	Alipur	4.0		x	
29	Dalapon	2.0			x
30	G-34690(25W) + CIPC	2.0 + 4.0		x	
31	HS-119-1	2.0			x
32	Cultivated + No Weeding				
33	Cultivated + Hand Weeding				
34	Check				

* Same day as planting

** 2 days prior to planting

Table II

Summary of Season's Observations and Yield, 1963
Location I

Treat. No.	Stand Counts			Weed Counts				Control ratings*		Injury rating**	Yield tons/A.	‰ Sucrose	Rainfall total/month (in.)
	1	2	3	1		2		BL	G				
				Br.	l.	Gr.	BL	G	BL	G			
1	128	42	40	11	29	9	17	6	1	5	14.4	21.7	1.89 Apr.
2	102	36	34	12	28	8	24	7	1	5	14.2	21.9	3.96 May
3	97	36	36	3	24	0	12	7	1	5	18.2	18.8	2.18 June
4	95	34	34	2	25	0	16	7	1	5	17.6	21.6	1.48 July
5	77	32	30	23	42	27	16	3	2	5	6.6	21.5	2.97 Aug.
6	62	30	27	44	34	31	19	4	2	3	3.9	19.8	2.02 Sept
7	112	37	33	58	34	39	16	2	2	5	8.7	20.9	0.11 Oct.
8	115	36	36	41	11	29	3	2	4	5	9.8	21.4	
9	8	7	7	29	6	25	2	6	4	1	3.3	20.1	
10	0	0	0	6	22	8	12	8	2	1	-	-	
11	5	5	5	29	24	37	15	6	1	1	1.3	15.9	
12	.25	0	0	12	22	10	20	8	1	1	-	-	
13	.25	.25	.75	7	14	9	19	8	3	1	-	-	
14	0	0	0	1	7	6	11	8	2	1	-	-	
15	4	0	0	17	36	13	14	6	1	1	-	-	
16	.25	0	0	5	10	7	6	8	3	1	-	-	
17	80	29	27	20	12	18	15	3	1	5	11.8	20.2	
18	82	31	30	32	26	22	22	4	1	5	9.6	21.0	
19	95	37	37	7	16	10	10	7	4	4	16.6	21.4	
20	86	36	35	13	17	8	4	7	4	5	14.0	19.4	
21	82	32	30	65	36	32	14	5	1	5	7.2	21.0	
22	76	33	33	4	17	7	5	7	5	4	16.4	20.7	
23	79	33	37	4	18	11	10	7	4	4	13.7	19.8	
24	114	38	35	37	30	38	22	2	1	5	7.6	21.4	
25	122	39	38	48	41	40	21	1	1	5	9.2	19.8	
26	110	37	36	54	23	44	21	1	1	4	9.8	21.2	
27	108	37	36	46	8	23	13	1	2	4	7.7	18.9	
28	4	4	5	5	10	3	24	8	3	4	3.4	18.6	
29	117	40	40	50	23	34	7	5	6	4	7.9	21.2	
30	7	2	3	4	32	8	24	9	3	1	1.8	15.7	
31	98	34	32	11	17	7	19	7	1	4	15.2	20.9	
32	115	37	33	65	50	36	11	2	1	5	9.0	19.9	
33	106	33	32	82	52	6	4	9	8	5	18.8	20.4	
34	109	36	31	91	31	56	15	1	1	5	8.6	20.5	

* 1 - No control 10 - Complete Control

** 1 - Complete kill 5 - No injury

BL = Broadleaf

G = Grass

Table III

Summary of Treatments, Observations, Yield and Rainfall, 1963

Treat. No.	Herbicide +	Rate/A. lbs. A.I.	Stand Counts			Location II				Control*		Injury ** rating	Yield tons/acre	% Sucrose	Rainfall total/ month (in.)
						Weed Counts									
						1		2		BL	G				
1	TD484	2.5	82	32	31	9	0	5	14	6	1	5	10.9	19.5	1.50 Ap.
2	TD484	3.5	72	33	31	5	0	5	22	7	1	5	11.3	18.8	3.21 Ma.
3	TD227	4.5	87	41	37	26	18	17	6	3	1	5	9.5	18.2	1.02 Ju
4	TD227	5.5	97	39	35	22	59	18	21	3	1	5	12.4	18.9	2.38 Ju
5	RC3056	5.5	84	36	35	2	1	1	5	8	1	5	12.2	18.6	3.74 Au
6	TCA + Endothal	8.0 + 2.0	85	37	35	8	2	8	1	8	5	5	11.3	18.7	1.77 Se
7	TD-291	4.5	79	35	33	16	9	8	9	7	1	5	11.7	20.0	
8	TD-291	3.5	78	35	35	27	32	11	21	4	1	5	9.3	18.1	
9	TD-492	5.5	74	37	36	20	20	14	28	5	1	5	10.1	18.0	
10	TD-492	6.5	95	37	38	12	15	5	15	6	2	5	10.3	18.8	
11	TD-428	4.5	89	41	35	5	5	5	10	8	5	5	10.5	19.1	
12	TD-428	5.5	83	37	32	6	6	5	5	8	6	5	11.8	19.0	
13	TCA + Endothal	9.375 +													
		5.625	76	32	33	20	10	11	4	6	7	4	11.3	18.2	
14	TCA + Endothal	6.875 +													
		4.125	86	36	37	6	4	7	4	8	7	5	9.8	19.4	
15	Pyramin	2.0	94	36	35	18	102	7	27	6	1	5	12.6	18.6	
16	Pyramin	3.0	77	32	30	8	8	8	5	8	4	5	10.5	19.7	
17	Pyramin	4.0	85	35	33	2	25	5	12	8	1	5	12.7	17.5	
18	Solubor	5.0	74	37	34	13	9	10	2	7	5	5	11.2	17.9	
19	Cultivated - No Weeding		96	38	36	19	15	12	13	4	6		11.0	18.0	
20	Cultivated & Hand Weeding		86	37	37	18	118	4	8	9	9		11.2	19.3	
21	Check		91	36	35	20	24	14	23	1	1		10.7	19.4	

+ - all treatments at planting as an 8" band

* 1- No Control 10 - complete control

**1- Complete kill 5 - no injury

the beets or left only a few hardy survivors. Initial injury was noted on treatments 6, 19, 22, 23, 26-29, 31, but the effects faded with the growth of the plant. Three stand counts were made as follows: 1. Prior to thinning, 2. At least two weeks after thinning, 3. Prior to harvest. Stand counts were made in 15' of each of the two center rows of the plot. Two weed counts were made, the first in late May and the second in early August. These were made in two separate locations in each plot. At location I the counts were made within a two square foot quadrat. At location II because of the banded application, counts were made within a 6 by 18" quadrat. Rainfall records were kept by the farmers.

Table I summarizes the treatments for location I; Table II summarizes the seasons observations and yield for location I. Table III summarizes treatments and observations for location II.

Conclusions

The following chemicals were not effective for weed control in sugar beets when used in the manner and amount indicated in the following:

TD 227	Tillam
TD 291	CP-32179
TD 492	CP-22819 plus Avadex

The following chemicals either killed the stand of beets completely or reduced it to a very few hardy plants:

G-36393 (25E and 25W)
 G-36393 plus CIPC
 G-34690 (25W) plus CIPC
 Prometryne
 Alipur

Solubor was effective on broadleaved weeds but did not control grasses, however, problems with mixing and application were encountered.

The most effective weed control treatment in both plots was hand weeding plus cultivation and consistent hoeing. This is indicative of not only a serious weed problem but one that is far from solved. The most promising herbicides were TCA and Endothal at 9.375# + 5.625# and 6.875# + 4.125# for overall annual grass and broadleaf weed control. Pyramin and HS-119-1 were superior to TCA + Endothal if only broadleaved weed control was considered. The compound best for suppression of Quackgrass was Dalapon at 2#/A post emergence. The beet yields from Dalapon alone were lower than Endothal plus Dalapon. This could have been due to the reduction in broadleaved weed competition in the latter treatment or a reduction in the injury from Dalapon when mixed with Endothal. Other compounds which showed definite promise: RC-3056, TD-484 and TD-428.

WEED CONTROL IN WINTER WHEAT ^{1/}Armin H. Furrer, Jr. and Stanford N. Fertig ^{2/}

This paper includes a discussion of three experiments conducted on the control of weeds in winter wheat:

- A. Fall treatments for the control of yellow rocket (Barbarea vulgaris) and common vetch (Vicia villosa)
 - B. Spring treatments for the control of yellow rocket, and
 - C. Spring treatments for the control of corn chamomile (Anthemis arvensis).
- A. Fall treatments for the control of yellow rocket (Barbarea vulgaris) and common vetch (Vicia villosa) in winter wheat.

Introduction

The use of 2,4-D as a fall treatment for weed control in wheat not seeded to legumes has been a standard recommendation. This treatment has resulted in injury to the crop. Control of some fall germinating species, such as yellow rocket and common vetch has been variable.

Materials and Methods

An area was located in winter wheat having a very heavy infestation of yellow rocket seedlings and a moderate stand of common vetch. Avon winter wheat had been planted on September 17, 1962. The chemicals used were diethanolamine salt of 2,4-D; ACP 62-70B liquid; and ACP 62-177, a wettable powder formulation of ACP 62-70. Treatments were applied on October 23, 1962. The weather was cloudy, moderately windy, and temperature 45 degrees F. At the time of treatment, the wheat was 5 to 7 inches tall, vetch seedlings 1 to 3 inches, and yellow rocket rosettes were 1 to 2 inches in diameter. Treatments were replicated 4 times. Plot size was 6 by 30 feet. Applications were made with a carbon dioxide knapsack sprayer at 30 gallons of liquid per acre.

Results and Discussion

Observations were made on November 21, 1962 and June 26, 1963. Wheat was harvested for grain yields. Table 1 shows the visual control ratings for yellow rocket and common vetch and the yield of wheat per acre.

The observations of November 21, 1962 indicated no visual injury to winter wheat except in treatments 6 and 7. ACP 62-70B at 1 pound per acre resulted in a slight necrosis of leaf tips, and moderate to severe necrosis of wheat at the 1.7 pound rate. No crop injury was

^{1/} Work supported in part by funds made available through Station Project Hatch 50.

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Table 1.

Fall Treatments and Visual Control Ratings of Yellow Rocket (Barbarea vulgaris) and Common Vetch (Vicia villosa)

Treat. No.	Chemical	Rate/A. lb. a.i.	Visual Weed Control Rating*		Yield, Bu/A. 14% moisture
			Yellow rocket	Common vetch	
1	2,4-D amine	0.25	3+	1	47.3
2	2,4-D amine	0.5	7	1	37.3
3	2,4-D amine	1.0	9	2	34.3
4	ACP 62-70B	0.25	4	4	46.8
5	ACP 62-70B	0.5	9	9	50.5
6	ACP 62-70B	1.0	9	9+	62.2
7	ACP 62-70B	1.7	9	9+	46.0
8	ACP 62-177	0.25	8	0	47.6
9	ACP 62-177	0.5	9	9	44.4
10	ACP 62-177	1.0	9	9+	47.6
11	ACP 62-177	2.0	9+	9+	49.0
12	Check	0.0	0	0	42.0

* Average of 2 replications; observations of June 26, 1963.

10 = complete control.

0 = no control.

observed in 1963. Weed species present in the check plots on the June 26, 1963 observations included yellow rocket, common vetch, ragweed, ox-eye daisy, field pepperweeds, corn chamomile, and perennial sow thistle.

Excellent control of yellow rocket and most other broadleaved weeds was obtained with 1 pound per acre of 2,4-D. Vetch control was rated poor.

The 1/2-pound per acre rate of ACP 62-70B and ACP 62-177 gave excellent control of yellow rocket and common vetch. A small number of ragweed, field pepperweed, and wild buckwheat plants were present in these treatments.

B. Spring treatments for the control of yellow rocket in winter wheat.

Introduction

Spring treatments were applied on an adjacent area of wheat for the purpose of comparison with fall treatments.

Materials and Methods

The chemicals used were the diethanolamine salt of 2,4-D and ACP 62-177 at the same rates used for the fall applications. An additional chemical, ACP 61-207, was included. Plot layout was similar to the fall treated area. Treatments were applied on April 13, 1963. Neither the

wheat nor weeds had made spring growth at this time. Observations were made on June 26, 1963. No wheat yields were taken.

Results and Discussion

Table 2 is a summary of the treatments and visual control ratings of yellow rocket. There was very little vetch in this area. The check plots were heavily infested with yellow rocket and quackgrass.

The herbicide 2,4-D at 1/2 pound per acre gave very good control of yellow rocket. At this rate, the spring application was more effective than the fall application.

Table 2
Spring Treatments and Visual Control Rating of Yellow Rocket
(Barbarea vulgaris)

Treat. No	Chemical	Rate/A. lbs. a.i.	Visual Control Rating* Yellow Rocket	
			June 26, 1963	
			Average of 2 Reps.	
1	2,4 -D amine	0.25	6+	
2	2,4 -D amine	0.5	8+	
3	2,4 -D amine	1.0	9+	
4	ACP 61-207	0.25	5	
5	ACP 61-207	0.5	6	
6	ACP 61-207	1.0	9+	
7	ACP 61-207	2.0	9+	
8	ACP 62-177	0.25	5+	
9	ACP 62-177	0.5	8+	
10	ACP 62-177	1.0	9	
11	ACP 62-177	2.0	9+	
12	Check	0.0	0	

* 10 = complete control

0 = no control

One pound per acre of ACP 61-207 gave excellent control of yellow rocket. Some ragweed, corn chamomile, and white cockle plants were present.

ACP 62-177 gave very good control of yellow rocket at 1/2 pound per acre. Spring treatments were slightly less effective than those applied in the fall.

- C. Spring treatments for the control of corn chamomile (Anthemis arvensis) in winter wheat.

Introduction

Corn chamomile (Anthemis arvensis) is a problem in the winter grain

growing areas of New York State. A preliminary report on control of this weed, erroneously called dog fennel (Anthemis cotula), was included in the 1963 Northeastern Weed Control Proceedings (1). In the preliminary investigations conducted in the spring and summer of 1962, three herbicides were effective in controlling corn chamomile: Banvel-D, ACP 62-70, and Silvex ester.

Materials and Methods

Treatments were applied on Avon winter wheat at 2 locations, designated as Area I and Area II, in the spring of 1963. The chemicals used were: ACP 62-177A, the wettable powder form of ACP 62-70; Dicamba, previously called Banvel-D; and silvex ester. The treatments are shown in Table 3. Treatment dates were as follows: on Area I, treatments 4 through 11 were applied on April 25, 1963 and treatments 1, 2, 3, 12 and 13 on April 30. All treatments on Area II were applied on April 30. Wheat was 6 to 10 inches tall on both areas. The corn chamomile rosettes, however, were larger on Area I than on Area II at the time of treatment. Other weeds present were: Area I - annual bluegrass (Poa annua); Area II - small seed false flax (Camelina microcarpa) and shepherd's purse (Capsella bursa-pastoris).

Observations on crop injury and weed control were made on May 21, and June 20. Wheat yields were obtained on Area II only.

Results and Discussion

Table 3 is a summary of the visual control ratings made on June 20 on Areas I and II and the wheat yields on Area II. No injury was observed on wheat by any of the treatments except Dicamba at 1/2 pound per acre where there was slight stunting in two replicates at Area II.

ACP 62-177A was ineffective in controlling corn chamomile on Area I but gave fair control on Area II at the 2-1/2 pound rate. Stage of growth or size of rosette appears to be critical with this compound. The rosettes must be small, preferably 1-1/2 inches or less in diameter at time of treatment. This chemical gave poor to fair control of small seed false flax and shepherd's purse.

Control of corn chamomile with silvex apparently is also influenced by size of rosettes, however, not as seriously as with ACP 62-177A. Good control can be expected with 0.8 pounds per acre. False flax was controlled with 0.67 pounds per acre.

Dicamba gave excellent control of corn chamomile on Areas I and II at 0.4 pounds per acre. The chemical controlled false flax at 0.4 and 0.5 pounds but was weak on shepherd's-purse.

Of the combination treatments, Dicamba plus Silvex ester at 1/4 plus 1/4 pounds per acre showed the most promise per unit of chemical for control of corn chamomile and other annual broadleaved weeds. Control of corn chamomile, false flax, and shepherd's-purse was excellent.

Table 3

Spring Treatment and Visual Control Ratings of Corn Chamomile in Winter Wheat

Treat. No.	Chemical	Rate/A. lbs. a.i.	Corn Chamomile Control Rating*		Yield
			Average of 4 Replications		Bu/A 14% Moisture,
			Area I	Area II	Area II
1	ACP 62-177A	1.5	0	4	43.3
2	ACP 62-177A	2.0	0	5	39.1
3	ACP 62-177A	2.5	0	6+	47.2
4	Silvex	0.67	4	7	42.3
5	Silvex	0.8	6	8	39.6
6	Silvex	1.0	8	9	42.9
7	Dicamba	0.25	6+	8	41.0
8	Dicamba	0.4	9	9	38.8
9	Dicamba	0.5	9	9+	37.2
10	Dicamba + Silvex	0.25 + 0.25	9+	9+	42.4
11	Dicamba + Silvex	0.25 + 0.5	9+	10	44.2
12	Dicamba + ACP 62-177A	0.25 + 0.5	8	9	45.9
13	Dicamba + ACP 62-177A	0.25 + 0.75	8	9	47.9
14	Check	0.0	-	-	35.2

* 10 = complete control

0 = no control

Summary

Three experiments were conducted on the control of weeds in winter wheat:

A. Fall treatments for the control of yellow rocket (Barbarea vulgaris) and common vetch (Vicia villosa)

Three chemicals were used: 2,4-D amine at 1/4, 1/2 and 1 pound per acre; ACP 62-70B and ACP 62-177 each at 1/4, 1/2, 1, and 2 pounds per acre. Excellent control of yellow rocket and most broadleaved weeds was obtained with 2,4-D at 1 pound per acre. Vetch control was poor. ACP 62-70B and ACP 62-177 gave excellent control of yellow rocket and common vetch at 1/2 lb/A.

B. Spring treatments for the control of yellow rocket.

Three chemicals were used: 2,4-D amine at 1/4, 1/2 and 1 pound per acre; ACP 61-207 and ACP 62-177 each at 1/4, 1/2, 1, and 2 pounds per acre. Very good control of yellow rocket was obtained with 1/2 lb. of 2,4-D per acre. At this rate, the spring application was more effective than fall. One pound per acre of ACP 61-207 gave excellent control of yellow rocket and ACP 62-177 gave very good control at 1/2 pound per acre.

C. Spring treatments for the control of corn chamomile (Anthemis arvensis).

The following chemicals were used alone and in combination with each other: ACP 62-177A, Dicamba, and Silvex.

The most promising treatments from the standpoint of effectiveness, crop tolerance, and control of other annual broadleaved weeds were:

Dicamba + Silvex at 1/4 + 1/4 pounds, Dicamba at 0.4 pounds, Silvex at 1.0 pound, and Dicamba + ACP 62-177A at 0.25 + 0.5 pounds per acre.

Bibliography

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EPTC INCORPORATION BY BAND PLACEMENT AND STANDARD METHODS
IN ESTABLISHMENT OF BIRDSFOOT TREFOIL 1/

D. L. Linscott and R. D. Hagin 2/

INTRODUCTION

The herbicide ethyl N,N-di-n-propylthiolcarbamate (EPTC) is one of the more effective herbicides available for use in establishment of legumes. EPTC kills most annual grasses and controls perennials such as quackgrass (*Agropyron repens*(L)Beauv.) and yellow nutgrass (*Cyperus esculentus* L.). In addition, it controls many broadleaved species (1). Broadleaved weeds that escape the chemical usually do not become a problem until the legume has passed the critical few weeks after seeding. Use of EPTC for weed control in establishing legumes increases chances for a successful seeding compared with conventional methods of underseeding with a cover crop. EPTC has a low residual life in soil as a further benefit (2,3). Forage may be grazed or harvested 60 days after herbicide treatment without danger of residues.

Birdsfoot trefoil (*Lotus corniculatus* L.) is difficult to establish. It has been estimated that only one third of legume seedings in New York are a complete success (4). The remaining two thirds are partially successful or complete failures. In spite of the obvious advantages, EPTC has not been readily adopted for weed control in the establishment of birdsfoot trefoil and other legumes in the Northeastern United States. Rates of material necessary and incorporation measures required for effective kill of weeds have resulted in a prohibitive cost for most farmers. Farmers are willing to invest substantially to insure establishment of perennial forages. However, unless the cost of using EPTC is decreased or ways are found to increase its effectiveness, the use of this promising herbicide for legume seeding establishment will be limited.

Wooten and McWhorter showed that subsurface applications increased the effectiveness of EPTC (5). Equipment designed by these two investigators for soils of the South did not appear practical for general use in soils of the Northeastern region. A method was needed that would be successful in soils often somewhat stony and varying from coarse to very fine in texture. Therefore, a modification in the concept of subsurface placement was required.

Studies were initiated in 1963 (1) to find methods of increasing the effectiveness of EPTC and thus reduce the quantity of chemical per acre required for weed control, (2) to develop better methods for establishing birdsfoot trefoil.

1/ Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Cornell University, Ithaca, New York.

2/ Research Agronomist and Agricultural Research Technician, U. S. Department of Agriculture, Agricultural Research Service, Cornell University, Ithaca, New York.

METHODS AND MATERIALS

(a) Band subsurface placement:

A conventional grain drill equipped with a grass seeder, fertilizer attachments and packer wheels was modified so that herbicides could be applied at the time of seeding below the soil surface.

Spray nozzles were attached to the boot assembly of a grain drill (Figure 1). The nozzle tips (8001) were positioned $2\frac{1}{4}$ inches above the bottom edge of the furrow opener. For this pilot model, flexible vinyl tubes were connected in series from a 3-gallon spray tank to the nozzles. Constant pressure (15 psi) was applied from a carbon dioxide cylinder. Modifications for use of standard pumps and tanks would be simple.

The angle of spray was adjusted to cover the furrow opened by the drill disk and boot assembly. Resulting spray patterns were 2 inches wide. Soil rolling back into place after passage of the drill disk opener and twin boot assembly covered the herbicide and effected a degree of mixing. No difficulty from nozzle clogging was experienced.

EPTC was applied at the time of seeding at rates of $\frac{1}{4}$ and 6 lb/A in the band (1.1 and 1.7 lb/A overall) in 75 gpa water (21 gpa overall). Viking birdsfoot trefoil was seeded in a band (10 lb/A) over the herbicide strip (Figure 2). Herbicide was present in the region $\frac{3}{4}$ to 2 inches below the seed. Seed depth was approximately $\frac{1}{8}$ inch. Fertilizer (350 lb/A 5-20-20) was placed 2 inches below the seed. Distance between rows was 7 inches. Packer wheels under tension compressed the seed-herbicide-fertilizer strip. Tractor-drill speed was 2 mph.

A short spray boom was mounted behind the packer wheels of the drill so that one half of the seeded area received a surface spray treatment in a 5 inch band between the rows in addition to an EPTC-incorporated band within the row. Atrazine was applied on the surface between the rows at rates of 0, 1, and 2 lb/A (0.7 and 1.4 lb overall). Similarly 2,4-D plus dalapon was applied on the surface in 5 inch bands at rates of 1 and 2 lb/A, 2,4-D plus $\frac{1}{4}$ lb/A dalapon (0.7 and 1.4 plus 2.9 lb/A overall). The surface herbicides were applied in 40 gpa water in the 5 inch band (29 gpa overall).

The experiment was conducted at two sites - one at Aurora, New York, on a Honeoye-Lima silt loam and the second at Ithaca, New York, on a Lucas silty clay loam. Seeding date for both sites was May 15. Both areas were planted to corn the previous year. Seedbed preparation consisted of plowing, disking, harrowing, and rolling. The experimental design was a randomized block with 4 replications. Plot size was 8 x 14 feet.

(b) Standard incorporation:

A study on incorporation by standard methods was conducted at Aurora, New York, on the site described previously. It was designed to compare standard methods of EPTC incorporation with variables of herbicide rates and number of incorporation treatments. The experiment was

Figure 1. Position of spray nozzle attached to the split boot assembly of a grain drill.

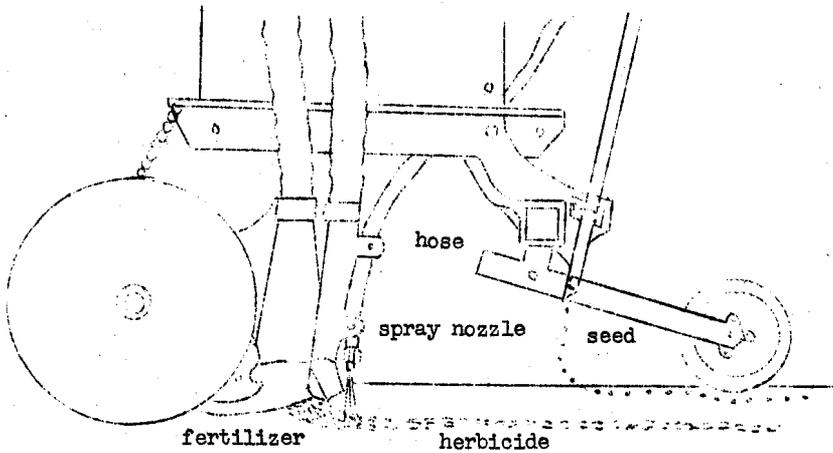
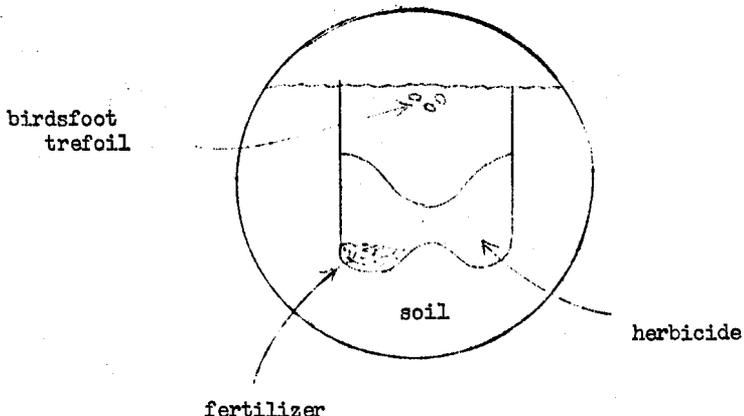


Figure 2. Relation between soil, seed, fertilizer, and herbicide in subsurface band-placement studies.



set up in randomized blocks with split-split plots and 6 replications. The size of each plot was 8 x 16 feet. Types and numbers of incorporations were as follows: 0, 1, 2, or 3 tandem diskings after herbicide application, and 1 rototilling after herbicide application. The tillage variable was minimized in that each plot had a total of 3 diskings or harrowings. Rototilled plots were disked or harrowed 3 times after which herbicide was applied and incorporated by tilling.

EPTC was applied with a hand boom at rates of 0, 2, or 4 lb/A in 30 gpa of water. Direction of disking and harrowing was alternated after each incorporation. The last incorporation was made within 5 minutes of the first within each block.

The experimental area was plowed April 25. Corn had been grown the preceding year. Plots were treated and seeded May 6. Ten lb/A of Viking birdsfoot trefoil was planted with a press drill equipped with fertilizer and seeder attachments. Fertilizer (0-20-20) was applied in a band at 350 lb/A.

RESULTS AND DISCUSSION

(a) Band subsurface placement:

Subsurface placement of EPTC in a band appears to be a highly promising technique for weed control in the establishment of birdsfoot trefoil. Broadleaved weed species, predominately wild mustard (Brassica kaber (DC), L. C. Wheeler), ragweed (Ambrosia artemisiifolia L.), red-root (Amaranthus retroflexus L.), and smartweed (Polygonum pensylvanicum L.), were reduced in stand by 65 percent after the application of 6 lb/A of EPTC on a band (1.7 lb/A overall) (Table 1). This same rate also reduced by 75 percent the stand of foxtail, nutgrass, and quackgrass. Little difference in weed stand resulted from 4 lb/A versus 6 lb/A EPTC in the band but there was a trend for better weed control at the higher rates.

Essentially all weeds were killed in the treated 2 inch band and for an inch on each side of the band (4 inch total). Weeds that survived were in a 3 inch strip between rows. Some nutgrass plants survived within the treated band but not in sufficient quantity to hinder trefoil establishment. Weeds surviving between bands appeared to be less vigorous than control plants indicating there may have been some movement of chemical vapor in the soil even beyond the effective kill region. Broadleaved species surviving EPTC effects to some extent were mustard and ragweed. Limited numbers of quackgrass and nutgrass survived.

The stand of birdsfoot trefoil was not affected by EPTC. Legume growth was slowed the first two weeks after emergence. However, decreased weed competition in treated plots ultimately resulted in more vigorous trefoil plants as compared with control plants.

The explanation for increased effectiveness of EPTC may be in the relative dilution. For example, 4 and 6 lb/A EPTC incorporated 4 inches in the soil by any tillage instrument would result in a chemical

Table 1. Stands and yields of legumes and weeds as affected by band subsurface placement of EPTC during the seeding operation at two New York locations.

Item measured and EPTC rate	Birdsfoot trefoil		Broadleaved weeds		Weed grasses	
	Caldwell : Aurora		Caldwell : Aurora		Caldwell : Aurora	
Plants/ft. ² ^{3/}	number	number	number	number	number	number
0 lb/A ^{1/}	16.2a	14.8a	4.2a	6.5a	18.3a	16.3a
1.1 lb/A	17.5a	15.0a	3.3ab	3.6b	8.3b	4.6b
1.7 lb/A	16.8a	15.8a	2.3b	2.5b	4.8b	4.2b
Pounds/acre: (Second cutting)	pounds	pounds	pounds	pounds	pounds	pounds
0 lb/A	297a	288a	317a	777a	595a	700a
1.1 lb/A	663b	762b	346a	748a	326b	307b
1.7 lb/A	768b	739b	327a	748a	249b	364b

- ^{1/} EPTC was incorporated in a two-inch band at rates of 4 and 6 lb/A in the band or 1.1 and 1.7 lb/A overall.
- ^{2/} Means in columns with the same letter are not significantly different at the 0.05 level according to Duncan's multiple range test.
- ^{3/} Plants were counted June 25-28 in 1/18 of the total area per plot which received EPTC alone. Each figure represents the mean of 20 plots.

distribution of 1 and 1½ lb/A inch, respectively. The band subsurface placement method as used in this experiment (4 and 6 lb/A EPTC in the band) resulted in EPTC concentrations of at least 2-3 lb/A inch. Probably, the effective concentration was greater in that EPTC was not mixed throughout the 2 inch layer. Weeds were killed outside the treated band indicating that EPTC may have moved through the soil air or water phases.

Forage yields of the band subsurface placement plots were taken at time of second cutting. Plots treated with EPTC yielded double the forage of the check. No difference in pounds per acre of broadleaved weed species between treatments was detected. Grass weed yields in treated plots were less than half of the check. Apparently reduction of grass competition allowed for more vigorous growth of legume and broadleaved weed species. Although the poundage of weeds was considerable in the second cutting, trefoil was well established.

Attempts to control weeds between the rows with atrazine, or 2,4-D and dalapon applied to the surface, resulted in considerable damage to birdsfoot trefoil. Legumes emerged nicely in both cases but died after a rain. Soil and herbicide from the treated region were washed in to contact with the legume plants and resulted in kill. The technique might have proved successful if a more narrow band of herbicide had been applied.

(b) Standard incorporation:

No significant differences were detected in stand of legume and weeds in the comparison of tandem disking and springtooth harrowing as methods of incorporating EPTC. Rototilling was the most satisfactory method of incorporation for elimination of broadleaved weeds (Table 2). Two or three incorporations with a disk or harrow compared favorably with a single rototilling for grass control. Four pounds of EPTC and a rototilling incorporation gave best control of broadleaved weeds. When broadleaved weeds are a problem, several incorporations are necessary to obtain adequate mixing in the soil if disks or harrows are used as the incorporating implements.

Stand counts of birdsfoot trefoil were not affected significantly by type of tillage or rate of chemical application (Table 2).

The weight of broadleaved weeds per acre in the second cutting was reduced little by herbicide or incorporation variables in spite of obvious differences in stand count (Table 3). Obviously the phenomena resulted from the decreased grass competition. Mustard and ragweed made up the bulk of surviving broadleaved weeds. Grass was essentially eliminated by 2 pounds of EPTC incorporated by a single disking or harrowing. Compared with controls, birdsfoot trefoil yielded 3 to 4 times as much in plots treated with 4 lb/A EPTC.

The effectiveness of band subplacement versus standard methods of incorporation cannot be compared directly in this experiment. However, it appears that the band treatments are promising and obviously cost a great deal less per acre for chemical.

CONCLUSIONS

Subsurface placement of EPTC in a band at the time of birdsfoot trefoil seeding was accomplished by attaching spray nozzles to the boots of a grain drill. In preliminary experiments EPTC applied in a band at 4 and 6 lb/A (1.1 and 1.7 lb/A overall) resulted in effective weed control and excellent establishment of birdsfoot trefoil.

Preplanting incorporation of EPTC at 4 and 6 lb/A by tandem disking, springtooth harrowing or rototilling resulted in adequate weed control for establishment of birdsfoot trefoil. No advantage of disking over harrowing could be detected. Rototilling was the best standard incorporation method.

Subsurface placement of EPTC in combination with the proved practice of band seeding and band fertilization may allow use of the herbicide at rates which are economical. Modification of equipment already available on many farms for subsurface placement of herbicide would be simple and inexpensive to accomplish. The practice warrants further consideration and research.

Table 2. Stands of legume and weeds as affected by tandem disking or springtooth harrowing and rototilling as methods of incorporating EPTC at various rates in the establishment of birdsfoot trefoil. ^{1/}

Type of plant and number of incorporations or method.	Plants/ft. ² for indicated rate of EPTC		
	0 lb/A	2 lb/A	4 lb/A
Weed grasses:			
	number	number	number
0 inc. ^{2/}	9.6a ^{3/}	6.9a	5.3a
	a	ab	b
1 inc.	8.8a	2.0b	1.7b
	a	b	b
2 inc.	7.8a	1.4bc	1.0bc
	a	b	b
3 inc.	8.3a	0.8bc	0.2c
	a	b	b
Rototilled	8.6a	0.7c	0.1c
	a	b	b
Broadleaved weeds:			
0 inc.	8.3a	7.6a	6.0a
	a	a	a
1 inc.	8.9a	7.3ab	4.0b
	a	b	c
2 inc.	8.8a	6.1ab	3.9b
	a	b	c
3 inc.	8.6a	5.6b	3.6b
	a	b	c
Rototilled	8.8a	3.0c	1.9c
	a	b	b
Birdsfoot trefoil:			
0 inc.	17.3a	17.4a	15.1a
	a	a	a
1 inc.	16.6a	16.1a	15.2a
	a	a	a
2 inc.	16.6a	16.8a	17.2a
	a	a	a
3 inc.	17.4a	16.8a	18.8a
	a	a	a
Rototilled	17.9a	18.7a	18.3a
	a	a	a

^{1/} Plants were counted before the first cutting.

^{2/} As effects of disking versus harrowing were not significantly different, data for the two incorporation methods were pooled.

^{3/} Means in rows or columns with the same letter are not different statistically at the 0.05 level according to Duncan's multiple range test.

Table 3. Yield of legume and weeds as affected by tandem disking or springtooth harrowing and rototilling as methods of incorporating EPTC at various rates in the establishment of birdsfoot trefoil. ^{1/}

Type of plant and number of incorporations or method.	Yield/acre for indicated rate of EPTC		
	0 lb/A	2 lb/A	4 lb/A
<u>Weed grasses:</u>			
	pounds	pounds	pounds
0 inc. ^{2/}	720a ^{3/}	662a	672a
	a	a	a
1 inc.	720a	48b	10b
	a	b	b
2 inc.	720a	10b	29b
	a	b	b
3 inc.	720a	10b	29b
	a	b	b
Rototilled	720a	19b	10b
	a	b	b
<u>Broadleaved weeds:</u>			
0 inc.	1190a	1123a	2205a
	a	a	b
1 inc.	1190a	1757a	988ab
	a	a	a
2 inc.	1190a	1104a	941b
	a	a	a
3 inc.	1190a	1689a	1853a
	a	a	a
Rototilled	1190a	1276a	768b
	a	a	a
<u>Birdsfoot trefoil:</u>			
0 inc.	418a	725a	679a
	a	b	b
1 inc.	418a	691a	1709b
	a	a	b
2 inc.	418a	923a	1315b
	a	b	c
3 inc.	418a	1166a	1615b
	a	b	b
Rototilled	418a	931a	1613b
	a	b	c

^{1/} Plant weights were obtained at the second cutting. Two of the six reps were sampled for yield.

^{2/} As effects of disking versus harrowing were not significantly different, data for the two incorporation methods were pooled.

^{3/} Means in rows or columns with the same letter are not different statistically at the 0.05 level according to Duncan's multiple

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PERFORMANCE OF NEW HERBICIDES ON SPRING GRAINS AND LEGUME SEEDING

A. Zaharchuk^{1/}

Procedure

The test area was planted on silty loam soil to single rows of Garry oats; Erie barley; Narragansett alfalfa; and Viking trefoil on May 13. The pre-emergence test was sprayed on May 14 using a hand operated small plot logarithmic sprayer (1) giving four half-dosages. The soil surface was dry with moisture below. Air temperature 60°F. Plot size 6 x 60 feet.

The postemergence plots were sprayed June 7, using the type sprayer described above. At the time of spraying the oats and barley were 7 to 8 inches; alfalfa 3 inches; trefoil 1½ inches; wild radish 4 to 5 inches; lambsquarters 1½ to 2 inches; hedge and field bindweed 12 to 18 inches; ragweed 1½ inches. The weeds and crops were dry at the time of spraying. Also the soil surface was dry. Air temperature 78°F. Plot size 6 x 60 feet.

Results

Results will be presented on the materials that appear promising for further development. Many of the materials tested lacked herbicidal activity or crop tolerance.

Pennsalt's B-377 gave excellent broadleaf weed control down to 3/4 lbs. applied preemergence. Alfalfa and trefoil were tolerant to the material starting at 1½ lbs. When applied postemergence alfalfa and trefoil were not tolerant to this material at the lowest rate used of 3/4 lb. It may be well to try lower rates postemergence as the control was excellent at the lowest rate used.

Geigy G-36393 applied preemergence gave excellent broad leaf control down to the lowest rate used of 3/4 lb. Alfalfa was tolerant to this material starting at the rate of 1½ lbs. Trefoil was not as tolerant as alfalfa. When applied postemergence alfalfa and trefoil were not tolerant to this material.

Columbia Southern BP-11 lacked herbicidal activity even at the highest rate used. Even though there was a lack of weed control oat and barley were killed down to the lowest rate used of 1½ lbs. This material may warrant further testing as a possible wild oat killer.

^{1/} Cooperative G.L.F. Exchange, Inc. Research & Development
Soil Building Division, Ithaca, New York

Green Cross CMPP applied postemergence gave excellent broad leaf control down to the lowest rate used of 3/8 lb. Oats and barley were tolerant to this material at the highest rate used of 6 lbs.

Amchem Butryac 118, used as a standard, gave excellent broad leaf weed control applied postemergence down to the 1½ lb. rate even though the weeds, especially wild radish, were quite large.

Conclusions

Of the new materials tested B-377 warrants further investigation on alfalfa and trefoil preemergence and lower rates postemergence. G-36393 warrants investigation preemergence on alfalfa. CMPP warrants investigation on grain crops postemergence.

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Residue Analysis of Alfalfa Treated with Trifluralin
and DCPA for Weed Control^{1/}

T. W. Kerr, P. B. Manning, C. E. Olney, and R. C. Wakefield^{2/}

The compounds trifluralin (a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) and DCPA (dimethyl 2,3,5,6-tetrachloroterephthalate) are relatively new herbicides being evaluated for control of annual grasses and broadleaf weeds in plantings of various crops. The investigation reported here was undertaken to determine whether measurable amounts of either herbicide would accumulate in the above-ground portions of new seedlings of Vernal alfalfa following soil application in the field.

The alfalfa was obtained from an experiment on chemical weed control reported by Wakefield and Pearson (1) elsewhere in this volume of the Proceedings. The seedlings were made in early May, 1963 using four randomly replicated plots per treatment. The amounts of active ingredient of trifluralin and DCPA applied as a spray, the former as a 4 pound per gallon emulsifiable concentrate and the latter as a wettable 75% powder, are presented in table 1. Harvest of the first crop of alfalfa treated with both materials was made on July 25. There were no samples of the second crop, but samples of a third crop from the DCPA treatment were obtained on October 17.

From each replicate at harvest approximately 400 grams (green weight) of alfalfa were placed in a polyethylene bag and frozen. Prior to analysis the alfalfa was finely chopped and, after mixing thoroughly, a subsample was taken. The analytical method for trifluralin was supplied by Eli Lilly and Company (2) and consisted essentially of extracting a 20 gram sample of alfalfa with hot methanol. After evaporating the methanol the residue was taken up in hexane, washed with water and chromatographed on florisil, eluting with hexane. The eluate was then concentrated, made to volume and the trifluralin measured by electron-capture gas chromatography. The procedure for determining DCPA was a modification of that described by Manning et al (3). Here a 50 gram sample of alfalfa was extracted with acetone and an aliquot of the filtered extract partitioned into hexane. After passage through an alumina column, DCPA was measured by electron-capture gas chromatography. In addition to analyzing the herbicide treated field samples, untreated alfalfa was fortified with trifluralin and DCPA to test the accuracy of the analytical methods. To the first crop of alfalfa 0.01 ppm of trifluralin was added for this purpose, while 0.5 ppm and 0.05 ppm of DCPA was added to the first and third crops, respectively.

^{1/}Contribution #1097 from the Rhode Island Agricultural Experiment Station, supported in part by funds from Regional Research Project NE-36.

^{2/}Entomologist, agricultural chemists and agronomist, respectively.

The results presented in table 1 show that in the first crop residues of trifluralin at both the one and two pound rates per acre were less than 0.01 ppm, the limit of sensitivity of the method. On the other hand, residues of DCPA ranged from 0.15 to 0.30 ppm. In the third crop of alfalfa residues of DCPA were 0.06 ppm in all four replicates. Trifluralin added to the alfalfa at the 0.01 ppm level was readily detectable, while 94 per cent and 92 per cent, respectively, of the DCPA in the fortified samples was recovered.

Table 1. Residues of trifluralin and DCPA in alfalfa seedings following application to the soil. Kingston, R. I. 1963.

Herbicide	Active toxicant lb./acre	Crop	Residue (ppm) in replicates			
			1	2	3	4
Trifluralin	1	First	< 0.01	< 0.01	< 0.01	< 0.01
	2	First	< 0.01	< 0.01	< 0.01	< 0.01
DCPA	8	First	0.17	0.15	0.25	0.30
		Third	0.06	0.06	0.06	0.06

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HERBICIDE EFFECTS ON HAY AND SEED PRODUCTION IN BIRDSFOOT TREFOIL

T. R. Flanagan and G. B. MacCollom

Although a great deal has appeared in the literature and has been presented here on the influence of herbicides on trefoil establishment and subsequent forage yields, relatively little information has come forth on the effects of weed killers on trefoil seed production. Fertig et al. (1), Schreiber (4), and we (3) had reported earlier that judicious applications of dalapon could reduce grass competition and enhance seed production. General conclusions were drawn that fall applications were safer on trefoil than spring applications; that Empire was more tolerant than the European types. Fertig (2) reported later that over 300 lbs. per acre of clean seed could be produced following dalapon treatments on Viking, and further that residual grass control was good. We concluded that early spring application of dalapon, timed to just after new spring growth initiation on Mansfield, effectively suppressed grasses and some broadleaf weeds, with resulting increased seed yields.

In 1961 seed yields were taken from a field of Viking, sprayed while dormant in early spring, with 2.5 lb. per acre a.i. dalapon and 1.0 lb. per acre a.i. of 4 (2,4-DB) (Table 1). Other fields of Mansfield were treated at about the same stage of spring growth with the same rate of dalapon (Table 2).

TABLE 1 - EFFECTS OF DALAPON ON TREFOIL YIELDS - 1961

Treatment	Trefoil %	Yields per acre of:		Cleaned seed lbs.
		Trefoil hay lbs.		
Dalapon	57.3	2110		48.6
4 (2,4-DB)	36.3	1880		29.2
Dalapon + 4 (2,4-DB)	47.3	1508		6.2
Unsprayed control	26.2	1036		39.1

TABLE 2 - EFFECTS OF DALAPON ON COMMERCIAL TREFOIL SEED FIELDS - 1961

Treatment	All hay lbs.	Yields per acre of:				Seed lbs.
		Trefoil lbs.	Trefoil %	Grass %	Weeds %	
Mansfield						
Dalapon	3166	2707	85	7	8	143
No spray	4094	2078	55	42	3	63
Empire						
Dalapon	4653	4177	90	2	8	258
No spray	5581	2411	43	50	7	146

A comprehensive study was established in April 1961, on an old, weedy stand of Mansfield, with a series of applications of dalapon plus 4 (2,4-DB) at the rates above, made on successive stages of new spring growth, from dormant to trefoil one foot tall (Table 3).

In 1962 dalapon at 2.5 lbs. per acre a.i. was applied with and without a series of insecticides (Table 4). Forage yield and seed harvests were taken from all of the above studies. In most cases the trefoil plants were hand separated out, and all data were subjected to mathematical analyses.

TABLE 3 - EFFECTS OF DALAPON + 4 (2,4-DB) ON MANSFIELD TREFOIL - 1961

Trefoil Growth Stage	All hay lbs.	Trefoil lbs.	Yields per acre of:			
			Trefoil %	Grass %	Weeds %	Seed lbs.
Dormant	6237	2893	47	5	48	67
1" growth	3012	2842	94	2	4	131
2-3" growth	4887	4617	94	3	3	48
4-6" growth	3756	3585	94	4	2	24
12" growth	3583	2671	77	4	19	9
No spray	3777	2302	61	32	7	100

TABLE 4 - EFFECTS OF DALAPON AND INSECTICIDES ON SEED YIELDS OF MANSFIELD TREFOIL - 1962*

Treatment:	Insecticide Average	Dalapon Alone	Dalapon + Insecticides	No Spray
Seed, lbs/A:	286.2	140.4	49.7	92.4

Averages for 6 treatments; four replications.

The 1963 studies included applications of several herbicides made on May 3, May 22, August 16 and 21 to a field of Mansfield in seed production. (Table 5).

The results of the 1961 test on Viking showed a fair increase in both hay and seed yields through dalapon use (Table 1). While the butyric 2,4-D reduced trefoil yields, the stand was somewhat improved. Considerable synergism from tank mixing the DB and dalapon resulted in improved trefoil stand but very serious seed reduction. The result of dalapon alone in other fields gave over 100% increase in seed yields in Mansfield; 80% increase in Empire seed harvested (Table 2).

The enhanced yields of seed from very early post-dormant spring applications of dalapon, as shown in the timed series of applications (Table 3) further substantiates our earlier conclusions (3). Although slightly later applications were best from an increased forage standpoint, serious seed

set reduction off-set any advantage.

Dalapon applied alone, and in combination with several insecticides, as a separate spray application, resulted in decreased yields. This also had been noted earlier for other insecticides (3). The serious yield reductions from the herbicide-insecticide combinations versus dalapon or insecticide alone indicated a possibility of activator effect on or in the plant on the part of the insecticide.¹

The current series of tests, still under way, have not been fully analysed as yet (Table 5). Presently available data show definite superiority of the lower rates of application versus the double rate. One exception is dalapon. It should be noted that the farmer oversprayed portions of the plot areas, including the dalapon plots, one week prior to treatment applications, with about 2 lb./A of Dowpon. Evidently the reversed response of the high rate of dalapon in the plots, giving higher yields was an indication that neither he, nor we at the low rate, had applied enough!

TABLE 5 - EFFECTS OF HERBICIDES ON HAY AND SEED PRODUCTION OF MANSFIELD TREFOIL - 1963

Treatment and rate*	Yields in pounds per acre:		
	Weeds	Trefoil	Seed
Simazine 80W 1½	2175	1425	28.5
" 3/4	2645	985	72.3
Dalapon 3	1885	1265	99.3
" 1½	1928	820	66.5
#4(2,4-DB) dimethylamine 1½	1320	1583	39.3
" " 3/4	2338	1250	65.0
#4(2,4-DB) iso-octyl ester 1½	1788	1428	48.8
" " 3/4	2478	1673	63.3
+4(2,4-DB) dimethylamine 1½	2545	1365	24.3
" " 3/4	2725	1528	38.5
+4(2,4-DB) butoxyethanol ester 1½	2073	868	21.0
" " 3/4	2583	2348	49.5
No spray	2810	1243	53.3

*Pounds per acre a.i. #Chipman's +Amchem's

Table 5 shows also that five treatments outyielded the non-sprayed check plots. This has not been completely verified statistically at this writing. Of the 4 (2,4-DB) plots these data will have to be compared with harvest data from the later dates of application for full interpretation. Indications are that the 3/4 lb. a.i. per acre rates are superior, and possibly that the dimethylamine salts are less injurious to trefoil.

1. This type of reaction has been discussed by A. S. Crafts in "The Chemistry and Mode of Action of Herbicides" pp. 236-245. Interscience. 1961.

In this latest series, both the D and T formulations of Diamond Alkali's dacamine were included. The early spring dormant applications of $3/4$ and $1\frac{1}{2}$ lbs. a.i. per acre of each of these resulted in almost complete elimination of all trefoil plants. These materials could have possible benefit in maintaining a trefoil-free isolation strip around fields in certified seed production.

Simazine looked particularly effective on several of the mustards and on field chickweed. The 4 (2,4-DB) esters and high rates of amine were more effective on dandelion, but not so efficient on chickweeds. They also were moderately effective on rough cinquefoil, an erigeron species, and on chicory.

From 4 (2,4-DB) applications made on May 22, only fair seed yields were harvested, due to increased trefoil injury. The two amine formulations reversed their position with more seed from the Amchem formulation. The iso-octyl ester formulation maintained apparent superiority over the butoxyethanol form however.

The above studies point out conclusively that only dalapon and dalapon alone is wholly safe to use on established stands of trefoil. The butyrics need more evaluation as to their weed killing efficiencies, especially with regard to rate and time of application.

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EFFECTS OF HERBICIDES AND MANAGEMENT FACTORS
ON ESTABLISHMENT OF ALFALFA SEEDINGS¹

R. C. Wakefield and J. O. Pearson²

Introduction

Management practices used in the establishment of alfalfa seedings largely reflect efforts to overcome weed competition. Herbicides have recently become available for farm use and promise to make possible a substantial yield of relatively weed-free hay during the seeding year (1,2,4). Where herbicides are used there would appear to be less concern with management factors such as planting of companion crops, avoidance of nitrogen fertilizers or early cutting of seedling growth (3,5). The present experiment was designed to study certain herbicide-management interrelationships as well as to evaluate newer herbicides.

Procedure

A weed control experiment was established on the Agronomy Peckham Farm on May 9, 1963. The area selected had a history of heavy weed infestation. Four replications were used in a randomized block design with individual plot size being 6 x 20 feet.

Fertilizer was broadcast to provide 100 lb/A P_2O_5 and 100 lb/A K_2O . Oats plots and nitrogen treatments received 50 lb N/A as urea. Vernal alfalfa was seeded at 12 lb/A and Clinton oats drilled at 50 lb/A.

Herbicides were applied in 30 gallons of water per acre with a bicycle-type sprayer. Chemicals are listed in the Appendix. The times of application and stages of plant development were as follows:

- a. Incorporated (EPTC & trifluralin) - May 9.
- b. Preemergence (diphenamid & DCPA) - May 9.
- c. Postemergence (4(2,4-DB) & dalapon) - June 6, alfalfa 3-4 true-leaves.

Rainfall

The soil was quite dry at time of seeding but .37 inch rain fell within 2 days. June rainfall was only 1.45 inches or 1.61 inches below normal. July rainfall was scanty during the first three weeks of the month. Growth of alfalfa was retarded considerably on the somewhat droughty Bridgehampton silt loam resulting in poor first cutting yields of alfalfa. Regrowth was further retarded by poor moisture conditions throughout August.

Plots were harvested on July 25 unless otherwise noted and all plots were harvested for second growth on September 12. A 3 x 14 foot strip was removed from each plot and weighed. Sub-samples were taken for dry matter determinations and botanical separations on all plots. Plant counts per square foot were

¹Contribution No. 1103. R.I. Agricultural Experiment Station, Kingston, R.I.

taken on October 3. Alfalfa root-crown weights were determined for plants dug from a one square foot area. Plants were clipped to 1 1/2 inches top growth and 6 inches root growth for these determinations of average plant size.

Results and Discussion

A summary of data obtained during the year of alfalfa establishment is presented in Table 1.

Weed Populations

The area selected for the experiment had a known high incidence of ladythumb (Polygonum persicaria), pigweed (Amaranthus retroflexus), ragweed (Ambrosia artemisiifolia), lambs quarters (Chenopodium album), spurry (Spergularia arvensis), yellow foxtail (Setaria lutescens) and barnyard grass (Echinochloa crusgalli). Distribution of most weeds was good within replicates. Spurry was less well distributed and occasionally dominant in patches.

Evaluation of 4(2,4-DB)

Two formulations of 4(2,4-DB), an amine and an ester, were evaluated at two rates. Results showed very little difference between either formulations or rates. There was no visible inhibition of alfalfa growth. Control of all broad-leaved weeds was excellent with the exception of spurry. Some degree of spurry control was gained only with a high rate of the ester material. The combination of 4(2,4-DB) with dalapon resulted in further suppression of spurry.

Grass-type weeds were not controlled by 4(2,4-DB). The combination with dalapon gave good control of both yellow foxtail and barnyard grass.

Nitrogen-treated plots sprayed with 4(2,4-DB) plus dalapon resulted in reduced broadleaf weed growth but greatly increased growth of grasses (treatment 14). Nitrogen obviously reduced the effectiveness of dalapon at the rate used.

Evaluation of EPTC

EPTC, incorporated into a dry seedbed, afforded excellent establishment of alfalfa plants as evidenced by plant counts taken in October (Table 1). All weed growth was controlled for several weeks after alfalfa emergence.

Control of grass-type weeds was complete and several broadleaf species were controlled fairly well. However, ragweed and wild radish were not controlled.

Supplementary plots treated with urea to supply 50 pounds N per acre, stimulated weed growth and reduced the apparent effectiveness of EPTC (treatment 15). The amount of broadleaved weed growth (mostly ragweed and wild radish) doubled in dry weight and grass weeds increased substantially.

Evaluation of Trifluralin, Diphenamid and DCPA

Trifluralin, diphenamid and DCPA gave excellent control of grass-type weeds. Trifluralin and diphenamid controlled most broadleaved weeds with the exception of late-germinating ragweed. Trifluralin was not as effective or as safe as

Table 1. Yields of alfalfa and weeds, alfalfa counts and alfalfa root-crown weights following herbicide and management treatments. Kingston, R.I. 1963.

Treatment	Lb/A A.I.	Yields - D.M. tons/A*			Plants/ sq. ft.	Root wts.
		Alfalfa	Broadleaf weeds	Grass weeds		
<u>HERBICIDES</u>						
1. 4(2,4-DB) amine	3/4	1.17	.26	.29	35.0	.76
2. 4(2,4-DB) amine	1½	1.03	.37	.28	29.5	.80
3. 4(2,4-DB) ester	3/4	1.25	.54	.25	26.0	.80
4. 4(2,4-DB) ester	1½	1.07	.38	.54	31.0	.71
5. Eptam	4	1.11	.70	.01	38.8	.66
6. 4(2,4-DB)-Dalapon	1½-1½	1.12	.41	.11	29.8	.74
7. Trifluralin	1	1.05	1.01	.01	34.3	.69
8. Trifluralin	2	1.04	.87	.01	24.3	.89
9. Diphenamid	4	1.18	.56	.03	30.3	.99
10. Diphenamid	6	.95	.75	.01	35.5	.78
11. DCPA	8	1.32	1.01	.02	34.0	.76
<u>MANAGEMENT FACTORS</u>						
<u>COMPANION CROP</u>						
12. Oats-silage (cut 7/16)		.53	.35	.06	22.0	.54
13. Oats-grain (cut 8/15)		.09	.36	.05	23.3	.41
<u>NITROGEN - 50 #/A</u>						
14. 4(2,4-DB)-Dalapon	1½-1½	1.21	.26	1.21	13.8	1.31
15. Eptam	4	1.06	1.43	.36	21.3	1.07
16. No herbicide		.95	1.85	.46	18.3	.79
<u>CUTTING TIME</u>						
17. Early - 7/10		.69	.90	.51	29.5	.57
18. Med. - 7/16		.82	.84	.32	34.5	.70
19. Late - 7/25 (Check)		.94	.70	.24	33.8	.72
L.S.D. (P = .05)		.31	.36	.26	9.3	.26

*Cuttings made on July 25 unless otherwise noted and on all plots on September 12.

Management Factors

Companion Crop

Oats were harvested at the silage and grain stages on July 17 and August 15, respectively. A substantial yield of 2.70 tons dry matter resulted from the silage "milk" stage cutting. The alfalfa component yield from this cutting plus the second cutting totalled .53 tons dry matter per acre. Weeds, particularly grass-types, were markedly reduced by the oats. However populations of alfalfa were also reduced and plants were small and lacked vigor. Similarly alfalfa underseeded to oats for grain developed thinner stands and small plants when compared to check plots.

Oat plots cut fairly early for silage returned a greater yield of forage than alfalfa plots treated with herbicides. Alfalfa yields were lower than expected due to dry weather. The full effect of oat competition on alfalfa stands and subsequent yields will not be known until the 1964 growing season.

Nitrogen Fertilization

Nitrogen fertilizer added to the seedbed of unsprayed plots (treatment 16) substantially increased the growth of broadleaf weeds, and to some extent grass-type weeds, when compared to check plots (treatment 19). As previously noted in sections of this paper dealing with specific herbicides, nitrogen increased growth of some weed species when the 4(2,4-DB)-dalapon mixture and EPTC were used.

It would appear that nitrogen reduced the effectiveness of dalapon since grass yields were markedly increased. Broadleaf weed growth was not increased, suggesting that nitrogen increased the effectiveness of 4(2,4-DB) particularly in view of nitrogen effects on unsprayed plots.

The apparent effectiveness of EPTC was reduced when nitrogen was used. Both broadleaved (mostly ragweed and wild radish) and grass weeds increased substantially.

Plant counts were reduced by nitrogen applications indicating possible injury from urea. Thinner populations of alfalfa resulted in larger average plant size.

Time of Cutting

Time of mowing had no significant effect on alfalfa yields and weed growth although interesting trends were noted. Alfalfa yields tended to increase while weed yields decreased as cutting was delayed. Delayed cutting had its most significant effect on reducing yields of grass weeds. This was largely due to less regrowth following the first cutting. Conversely, early cutting resulted in a substantial yield of grass weeds in second growth (.45 tons/acre) compared to late cutting (.01 tons/acre).

Summary

Herbicides and management factors were evaluated on a spring seeding of

Good control of broadleaf weeds was achieved with 4(2,4-DB) with no differences between rates of 3/4 and 1 1/2 pounds per acre or between amine and ester formulations. Grass-type weeds were controlled by a 4(2,4-DB)-dalapon mixture.

EPTC controlled grass and broadleaved weeds with the exceptions of wild radish and ragweed. Diphenamid gave excellent control of all but late-germinating ragweed. Trifluralin gave good control of grass-type weeds and fair control of broadleaved weeds but caused some injury and reduction in alfalfa plants at a 2-pound rate.

Oats gave excellent yields of dry matter with good suppression of weed growth but caused reduction in alfalfa stands and size of plants.

Nitrogen fertilization substantially increased growth of weeds, particularly broadleaved-types. Nitrogen decreased the effectiveness of dalapon in controlling grass weeds, and EPTC in controlling both broadleaved and grass weeds. Results suggested that nitrogen increased the effectiveness of 4(2,4-DB) in controlling broadleaved weeds.

Delayed cutting of untreated alfalfa favored control of weeds, particularly grass-types.

Literature Cited

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Appendix

Herbicides used in this study were as follows: (Companies supplying materials are noted.)

1. 4(2,4-dichlorophenoxy) butyric acid, dimethylamine salt and iso-octyl ester. 4(2,4-DB) Each 2 lb A.E./gal. Chipman Chemical Co., Amchem Products.
2. Ethyl n,n-di-n-propylthiolcarbamate (EPTC) 6 lb A.E./gal. Stauffer Chemical Co.
3. 2,2-dichloropropionic acid, sodium salt 74% A.E. (Dalapon). Dow Chemical

4. 2,6-dinitro-N,N-di-n-propyl-a,a,a-trifluoro-p-toluidine (trifluralin)
4 lb A.E./gal. Eli Lilly and Co.
5. N-N-dimethyl 1-2,2-diphenylacetamide (diphenamid), 80% active. Eli Lilly
and Co.
6. Dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) 75% active. Diamond Alkali
Co.

THE ESTABLISHMENT OF SEEDINGS OF FIVE SPECIES OF FORAGE LEGUMES IN RESPONSE TO CERTAIN PREPLANT, PREEMERGENCE OR POSTEMERGENCE HERBICIDE TREATMENTS

O. E. Rud ^{1/}

Spring seedings of forage legumes are often severely affected by competition from weeds. The use of a companion crop in which seedings are made has been a common practice. The use of herbicides as a substitute for a companion crop has shown promise in recent years. This report presents the results of one season's work in evaluating several herbicide treatments.

Experimental Methods: The objectives were to (1) evaluate the effect of selected herbicide treatments on the yield of forage and weed seedlings that established and (2) to evaluate the same treatments on the forage species in the absence of association with weeds. Due to lack of space, only brief reference will be made to the results of the second objective. Spring seedings of alfalfa, red clover, ladino clover, birdsfoot trefoil, and annual lespedeza were used. Herbicide treatments were of three types: (a) preplant incorporated, (b) preemergence, (c) postemergence. The following treatments were evaluated: weedy check, weed-free check; preplant incorporated: Eptam 2½ and 5 lb., R1607 (n-propyl-di-n-propylthiolcarbamate) 2½ and 5 lb., trifluralin ½ and 1½ lb.; preemergence: diphenamid (Dymid 50W) 2,4,8 lb., diphenamid (Enide 50W) 2,4,8 lb., R4572 (ethyl-1-hexamethyleneiminecarbothiolate) 2,4 lb.; postemergence: 2,4-D dimethylamine ¼, ½ lb., MCP dimethylamine ¼, ½ lb., 4 (2,4-DB) dimethylamine 1,2 lb., 4(2,4-DB) butoxyethanol ester 3/4, 2 lb., 4(MCPB) butoxyethanol ester 3/4, 2 lb., 4(MCPB) dimethylamine 1,2 lb., oleyl 1,3-propylene diamine salt of 2,4-D (dacamine 4D) ¼, ½ lb.

The study was conducted on a silt loam soil at Blacksburg, Virginia. Three rows one foot apart were seeded across plots 7 feet wide and 27 feet long. The randomization within replicates was restricted so that each species occurred once across the long axis of the plot so that incorporation with field machinery could be done effectively. Three replicates were used. Herbicides were applied with a modified knapsack sprayer using compressed air regulated at 30 p.s.i. Spray volume was approximately 38 g.p.a. Pre-plant incorporation treatments were applied May 16, 1963, and immediately worked into the upper 1 or 1½ inches with a tractor mounted power take-off rotary hoe. Seeding was done on May 20 with a Planet Jr. manually propelled seeder. Preemergence treatments were applied on May 20. Postemergence treatments were applied on June 17. The area was sprinkler irrigated four times during the experimental period with the first application on the third day after seeding. A heavy and uniform stand of lambsquarter (Chenopodium album) and red root pigweed (Amaranthus retroflexus) with a light and scattered infestation of black nightshade (Solanum nigrum) occurred. Some grasses, mainly Panicum and Digitaria appeared late.

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Evaluations were made by harvesting three one-foot square samples of weeds per treatment and the growth of each forage species on three one foot length of row on July 29. Air dry weights of forage, weeds, the numbers of weeds and average height were determined.

In the phase of the work in which the treatment effects were evaluated on the species in the absence of association with weeds during the duration of the study, seedings were established in small plots by hand seeding, using a measured volume of seed of each species. Treatments were applied on different dates than the large field plots, but at comparable stages of development.

Results and Discussion: Average dry weight production of forage is shown in Table 1. Weeds very significantly reduced the yield of all species. Trifluralin at $\frac{1}{2}$ lb., 4(2,4-DB) ester at $\frac{3}{4}$ and 2 lbs. resulted in forage yields for all species as high as the weed-free check. R1607 at 5 lb. and trifluralin at $1\frac{1}{2}$ lb. resulted in yields as good as weed-free check in all species except lespedeza. 4(2,4-DB) ester at both rates performed well, as did 4(2,4-DB) amine at the 2 lb. rate. Red and ladino clover were intolerant to all rates of diphenamid; birdsfoot trefoil and lespedeza were intermediate; and alfalfa was tolerant to all rates used. Black nightshade invaded the diphenamid treated plots. Diphenamid treatments on species in the absence of weeds showed the lack of tolerance of ladino and red clover, the rate response of birdsfoot trefoil and lespedeza and the tolerance of alfalfa to the herbicide.

Weed weights, numbers and characteristics (wt. x no.) are shown in Table 2. Weed weights and weed numbers do not contribute equally to the effect on forage yield resulting from a treatment. The characteristic of the canopy has a greater influence than weed numbers. As an example, Eptam at 5 lb. had a significant reduction in weed numbers but not in weed yield when compared to the weedy check. Weed control was evident for a short period, after which these fewer weeds developed into larger and as dense a canopy as the more numerous plants in the check. Generally, the postemergence treatments had weed numbers as great as the check, but weed yields were less, due to the suppression of growth due to the herbicide. There was some evidence from information from the species responses to the treatments that some association between the reaction of the species to a treatment is related to the establishment and yield of that species when that treatment is used as a potential weed control treatment in seeding establishment. This phase will require more work for resolution. Results have not been consistent with other workers' results using trifluralin ^{2/}.

^{2/} PETERS, R. A. and H. C. Yokum. Further evaluation of herbicides for weed control in new seedings of alfalfa. Proc. NEWCC 16:299-302. 1962.

Table 1. The effect of herbicide treatments on the yield of five species of legumes. Planted May 20, harvested July 29.

Treatments	Lbs/A ae. ai.	Average Yield Per Plot, Grams				
		Alfalfa	R.Clo.	Ladino Clo.	B.F.Tre.	Ann.Leas.
Check, weedy	-	3	4	8	5	3
Check, weed-free	-	83	144	115	85	99
Eptam pr.pl.inc.	2½	15	43	15	21	7
Eptam pr.pl.inc.	5	16	33	22	38	13
R1607 pr.pl.inc.	2½	7	26	9	12	6
R1607 pr.pl.inc.	5	54	117	120	87	28
Trifluralin pr.pl.inc.	½	71	272	145	128	78
Trifluralin pr.pl.inc.	1½	100	223	90	127	16
Dymid pre	2	23	-	-	20	33
Dymid pre	4	76	-	-	12	23
Dymid pre	8	19	-	-	-	4
Enide pre	2	44	-	-	21	47
Enide pre	4	39	-	-	10	41
Enide pre	8	32	-	-	-	17
R4572 pre	2	9	12	3	7	3
R4572 pre	4	4	15	5	7	2
2,4-D A post-e	½	14	73	13	19	20
2,4-D A post-e	½	15	98	37	27	27
MCPA post-e	½	9	58	11	28	13
MCPA post-e	1	14	127	61	11	25
4(2,4-DB) post-e	1	14	156	72	30	33
4(2,4-DB) post-e	2	44	127	79	60	58
4(2,4-DB)E post-e	3/4	49	233	134	43	71
4(2,4-DB)E post-e	2	54	211	199	63	63
4(MCPB)E post-e	3/4	15	118	29	22	41
4(MCPB)E post-e	2	27	141	88	12	59
4(MCPB)A post-e	1	22	130	16	20	37
4(MCPB)A post-e	2	22	98	99	15	33
Dacamine 4-D post-e	½	15	56	37	20	22
Dacamine 4-D post-3	½	9	117	86	18	24
LSD .05		24	108	81	26	30

Table 2. Herbicide treatment effect on air dry weight of weeds, numbers of living weeds and characteristics of weed population

Treatment	Rate, lb/Ac. ai.,ae.	Weight, Grams	Number	Height Number $\times \frac{1}{L}$
Check, weedy	-	732	98	1680
Check, weed-free	-	0	0	0
Eptam, pr.pl.inc.	2½	556	98	1831
Eptam, pr.pl.inc.	5	541	34	645
R1607 pr.pl.inc.	2½	642	62	1173
R1607 pr.pl.inc.	5	283	18	252
Trifluralin pr.pl.inc.	½	130	13	140
Trifluralin pr.pl.inc.	1½	47	2	20
Diphenamid,Dymid pre	2	480	40	986
Diphenamid,Dymid pre	4	353	16	361
Diphenamid,Dymid pre	8	594	25	481
Diphenamid,Enide pre	2	342	33	811
Diphenamid, Enide pre	4	364	30	563
Diphenamid,Enide pre	8	253	13	343
R4572 pre	2	640	208	3165
R4572 pre	4	825	148	2642
2,4-D A post-e	½	453	140	1089
2,4-D A post-e	½	209	83	314
MCPA post-e	½	484	109	585
MCPA post-e	½	300	159	834
4(2,4-DB)A post-e	1	186	113	660
4(2,4-DB)A post-e	2	73	19	91
4(2,4-DB)E post-e	3/4	136	60	348
4(2,4-DB)E post-e	2	53	57	646
4(MCFB)E post-e	3/4	216	167	957
4(MCFB)E post-e	2	123	35	181
4(MCFB)A post-e	1	280	156	1005
4(MCFB)A post-e	2	110	37	145
Dacamine 4D post-e	½	275	117	534
Dacamine 4D post-e	½	325	155	671
L.S.D. .05		250	64	538

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Value representing average height of weeds multiplied by the average numbers of weeds per unit area.

Summary: Preplant incorporation, preemergence and postemergence treatments were evaluated in the establishment and yield of seedlings of five species of forage legumes when grown in association with weed species.

R1607 and trifluralin as preplant incorporated treatments showed effective weed control and resulted in good seedings.

Forage species evaluated, except alfalfa, showed a varying degree of selectivity to diphenamid preemergence treatment.

Many treatments, particularly postemergence phenoxy or butyric forms of 2,4-D and MCP altered the characteristics of the weed canopy, this alteration often resulting in more favorable establishment of seedings. Evaluations of weed effects using weights or number of weeds times average height usually indicate a more representative evaluation than numbers alone.

Acknowledgment is made to the following chemical companies for furnishing materials: Stauffer Chemical Company, Eli Lilly Company, the UpJohn Company, Velsicol Chemical Company, Anchem Products, Inc., Diamond Alkali Company.

THE USE OF GRASS-KILLING HERBICIDES IN ESTABLISHING
GRASS-LEGUME MIXTURES¹

Jonas Vengris²

ABSTRACT

During the 1960, 1961 and 1962 growing seasons four field experiments were conducted to investigate the susceptibility of orchardgrass, Dactylis glomerata L. and timothy, Phleum pratense L. to injury from applications of 2,2-dichloropropionic (dalapon) and trichloroacetic (TCA) acid salts. To control broadleaved weeds 4-(2,4-dichlorophenoxy) butyric acid (4- [2,4-DB]) was used. Pre-emergence and post-emergence applications of TCA and post-emergence applications of dalapon controlled common annual weedy grasses. Slightly higher rates of application of TCA are required for post-emergence treatments than for pre-emergence treatments to give the same results. TCA as well as dalapon injured orchardgrass, timothy and alfalfa but these plants usually regained normal growth later in the season and produced satisfactory stands. Dry weather and soil conditions in the first half of the growing season of 1962, increased injury to newly seeded grasses by dalapon significantly.

The use of 4-(2,4-DB) controlled 2-3 inch seedlings of common broadleaved weeds quite effectively. Timothy suffered more from weed competition than orchardgrass, hence gave greater response to early weed control practices. The value of the herbicidal treatments should be measured by both the improved quality and quantity of hay produced in the year of seeding.

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EFFECT OF ENSILING ON THE DEGRADATION OF
4-(2,4-DB), DALAPON AND AMITROLE. (Abstract)^{1/}

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Degradation of 4-(2,4-dichlorophenoxy)butyric acid, [4-(2,4-DB)] in legume silage as affected by time and sugar additives was studied. In a laboratory experiment herbicide was sprayed on chopped forage at rates of 0 and 250 ppm. Sugar was mixed with the forage at rates of 0, 50, and 500-lbs/ton. Treated forage was packed in glass jars and allowed to ferment for 0, 1/3, 15, and 30 days. Samples of the resulting silage were analyzed for residual herbicide by ultraviolet spectroscopy and electron capture gas chromatography. Approximately 55 percent of the 4-(2,4-DB) applied was degraded in 30 days as the result of fermentation. The degradation rate was greatest immediately after ensiling. However, measurable degradation occurred during the entire experimental period. Addition of sugar as an energy source resulted in slightly less degradation of herbicide.

Birdsfoot trefoil was sprayed in the field with 4-(2,4-DB) at rates resulting in approximately 0, 10, and 200 ppm of herbicide in the forage. Chopped birdsfoot trefoil forage was ensiled under pressure in metal tanks with capacities for 60 pounds of forage. Six months after ensiling, samples were analyzed for 4-(2,4-DB) by electron capture gas chromatography. Over 50 percent of the 4-(2,4-DB) was degraded during the fermentation period. Degradation was more pronounced at high compared to low initial herbicide concentrations in the silage.

In similar research, the effects of ensiling on 2,2-dichloropropionic acid (dalapon) and 3-amino-1,2,4-triazole (amitrole) were studied. No degradation of either compound was detected.

^{1/} Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Cornell University, Ithaca, New York.

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WEED CONTROL IN LEGUME SEEDLING ESTABLISHMENT IN NORTHERN NEW YORK

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Forage crops are the foundation of the dairy industry in the Northeast and the quantity and quality of forage produced on the farm has been an important key to success or failure. Each year, a part of the acreage on most dairy farms is seeded to legume or legume-grass mixtures to meet the forage needs as pasture or hay. Even though this low cost source of nutrients is of major importance, farmers have been slow in adopting improved practices which would insure better stands of forage. The problems associated with establishing good stands and harvesting quality forage run from plowing to storage and include: seedbed preparation, planting problems, inoculation, lime and fertility level, weed control, winter injury, grazing management, cutting schedule, curing and storage.

The weed species encountered in seedling establishment are predominately annual broadleaves and annual grasses. The important perennial species is quackgrass.

The 5 county area of northeastern New York is a major dairy farm region. The soils vary from sands to very heavy clays, well to poorly drained, and droughty to wet.

Presently, 90 percent of the acreage devoted to forage is seeded with oats as a companion crop. There are three reasons for this: (a) to obtain some income in feed or cash the year of seeding, (b) to obtain bedding for the dairy herd, and (c) as a weed control measure. The small grain makes a significant contribution to the control of annual grasses up to the time it is harvested but is of little value in suppressing the annual broadleaved species. The small grain does play a major role in suppressing the rapid establishment of the legume-grass seeding. Also, due to lodging of the small grain and to volunteer growth of the small grain lost in combining, many new seedings are killed out before they have the chance to become established.

METHOD AND PROCEDURE

In the spring of 1962, legume seeding establishment plots were initiated in two counties in Northern New York. A third experiment was initiated in the spring of 1963.

An alfalfa-timothy mixture was seeded alone and with oats as a companion crop in Lewis County. In St. Lawrence and Franklin Counties the seeding mixture included alfalfa-birdsfoot-timothy. The plots were managed the seeding year according to the schedule in Table 1.

^{1/} Professor, Associate Professor and Research Specialist, respectively, Department of Agronomy, Cornell University, Ithaca, New York.

Table 1

Treat. letter	Chemical	Rate lbs./A.	Companion crop used	Stage of harvest in relation to oats	Key to Treatments			
					Rep I	Rep II	Rep III	Rep IV
a	-	-	none	silage	1	24	41	59
b	-	-	oats	grain	6	19	37	49
c	Sinox PE	1-1/8	none	silage	11	17	34	56
d	"	"	none	grain	5	30	42	53
e	"	"	oats	silage	14	25	36	63
f	"	"	"	grain	15	23	46	57
g	4(2,4-DB)	1-1/2	none	silage	7	27	44	50
h	"	"	none	grain	16	28	33	58
i	"	"	oats	silage	12	29	48	51
j	"	"	oats	grain	2	31	35	55
k	2,4-D	1/4	none	silage	3	22	40	64
l	"	"	none	grain	8	21	39	61
m	"	"	oats	silage	13	20	43	60
n	"	"	oats	grain	4	26	45	52
o	Dalapon + 4(2,4-DB)	2 1-1/2	none	silage	9	32	47	54
p	"	"	none	grain	10	18	38	62

Treatments e, i, and m seeded with oats as a companion crop were harvested at the silage stage of the oats. A second cutting was made on August 29. Treatments b, f, j, and n were harvested at the grain stage of the oats on August 29 and only one harvest was taken. Treatments a, c, g, k, and o seeded without oats, were harvested at the same time as e, i and m. Treatments d, h, l, and p were harvested on the same schedule as b, f, j and n. Also, for each management situation, shown in Table 1, individual plots replicated 4 times received post-emergence treatments of Dinitro amine - 1-1/8 lbs., 4-(2,4-DB) amine - 1-1/2 lbs., 2,4-D amine - 1/4 lbs., and 4-(2,4-DB) amine + dalapon - 1-1/2 + 2 lbs. Check treatments, with and without the companion crop were included.

Data obtained in 1962 included first year yields of forage when harvested at the silage stage of oats, yields when harvested at the mature grain stage of oats, yield of oats as silage and yield of oats as grain. Botanical separations were made on all plots harvested at the silage stage of oats. The percentage of alfalfa, grass and weeds was determined and the weeds identified as to species.

During the summer of 1963, two harvests were taken from the plots in Lewis (Table 3) and 3 harvests from the plots in St. Lawrence County (Table 4). The new location established in the spring of 1963 was managed in the same manner as described for the 1962 plots. The 1963 harvest yields are reported in Table 5.

RESULTS AND DISCUSSION

Although good control of some species of annual broadleaved weeds was obtained with all chemicals in the 1962 trials, the Dinitro amine controlled the widest range of weed species and was the most consistent. Dinitro was the only chemical which controlled hemp nettle (Galeopsis tetrahit). This, along with corn spurry (Spergula arvensis), were the most prevalent species in the Lewis County plots. The weed species recorded most frequently in the stand counts and the effectiveness of control are reported in Table 2.

Table 2

Weed Species	Chemical Treatment and Control Ratings								
	Dinitro amine			4(2,4-DB) amine			2,4-D amine		
	poor	fair	good	poor	fair	good	poor	fair	good
Barnyard grass	x			x			x		
Broadleaved plantain			x			x			x
Common mustard			x			x			x
Corn spurry		x		x			x		
Dandelion	x			x			x		
Hemp nettle			x	x			x		
Horse nettle	x			x			x		
Lady's-thumb	x					x		x	
Milkweed	x			x			x		
Quackgrass	x			x			x		
Ragweed	x					x			x
Sheep sorrel	x				x			x	
Shepherd's-purse			x			x			x
Vetch	x			x			x		
Yellow rocket			x		x		x		

Table 3
Forage and Small Grain Yields in Legume Seeding Establishment - Lewis County

Treat. No.	Chemical	Rate/A. lbs. a.i.	Companion crop	Stage of harvest in relation to oats*	Dates of harvest and small grain and forage yields for 1962 and 1963				
					Forage yield 1962	Oat yield 1962	Date and yield of forage for 1963. 15% moisture hay		
							6-22-63	8-15-63	
1	Check	-	none	silage	1.97	1.28	The	1.94	1.47
2	Check	-	oats	grain	----	2.01		2.06	1.18
3	Sinox P.E.	1-1/8	none	silage	1.81	1.44	oats	1.87	1.40
4	Sinox P.E.	1-1/8	none	grain	----	2.05	for	2.53	1.45
5	Sinox P.E.	1-1/8	oats	silage	2.34	1.20	grain	1.90	1.24
6	Sinox P.E.	1-1/8	oats	grain	----	2.19	plots	2.00	1.38
7	4(2,4-DB) amine	1-1/2	none	silage	1.66	1.37		1.77	1.35
8	4(2,4-DB) amine	1-1/2	none	grain	----	2.24	shattered	2.44	1.28
9	4(2,4-DB) amine	1-1/2	oats	silage	2.45	1.01		2.00	1.02
10	4(2,4-DB) amine	1-1/2	oats	grain	----	2.34	so	2.13	1.22
11	2,4-D amine	1/4	none	silage	1.78	1.14	badly --	2.22	1.01
12	2,4-D amine	1/4	none	grain	----	1.94	not	2.45	1.20
13	2,4-D amine	1/4	oats	silage	2.36	1.00		2.34	1.12
14	2,4-D amine	1/4	oats	grain	----	1.99	recorded	2.18	1.44
15	4(2,4-DB) + dalapon	1-1/2 + 2	none	silage	1.39	1.29		1.67	1.29
16	4(2,4-DB) + dalapon	1-1/2 + 2	none	grain	----	1.73		2.24	1.50

* Where no companion crop was used, the forage was harvested at the same time as the oats were taken for silage - late milk to early dough stage. Where the stage of harvest was grain, the forage was harvested at the same time as the oats were taken for grain yields.

Table 4

Forage and Small Grain Yields in Legume Establishment - St. Lawrence County

Treat. No.	Chemical	Rate/A. lbs. a.i.	Companion crop used	Stage of harvest in relation to oats*	Dates of harvest and small grain and forage yields for 1962 and 1963					
					Forage and oat yields - 1962			Forage yields for 1963, 15% Mo hay		
					1st.	2nd.	(Bu.)	6-15-63	8-8-63	10-10-63
1	Check	-	none	silage	1.06	0.97		3.48	1.36	0.89
2	Check	-	oats	grain	----	2.05	48.3	3.17	1.43	0.91
3	Sinox P.E.	1-1/8	none	silage	0.71	1.08		3.15	1.59	0.93
4	Sinox P.E.	1-1/8	none	grain	----	2.00		3.32	1.53	0.88
5	Sinox P.E.	1-1/8	oats	silage	1.83	0.76		3.35	1.26	1.02
6	Sinox P.E.	1-1/8	oats	grain	----	1.95	63.0	3.13	1.27	0.99
7	4(2,4-DB) amine	1-1/2	none	silage	0.79	1.06		3.15	1.50	0.98
8	4(2,4-DB) amine	1-1/2	none	grain	----	1.82		3.21	1.45	0.94
9	4(2,4-DB) amine	1-1/2	oats	silage	1.82	0.65		3.14	1.35	1.02
10	4(2,4-DB) amine	1-1/2	oats	grain	----	1.73	58.5	3.29	1.48	0.83
11	2,4-D amine	1/4	none	silage	0.81	1.03		3.15	1.32	1.00
12	2,4-D amine	1/4	none	grain	----	2.10		3.44	1.55	0.98
13	2,4-D amine	1/4	oats	silage	2.05	0.54		3.29	1.41	0.93
14	2,4-D amine	1/4	oats	grain	----	1.66	58.4	3.56	1.34	0.92
15	4(2,4-DB) + Dalapon	1-1/2 + 2	none	silage	0.86	1.06		3.08	1.27	0.95
16	4(2,4-DB) + Dalapon	1-1/2 + 2	none	grain	----	1.94		3.32	1.59	0.98

* Where no companion crop was used, the forage was harvested at the same time as the oats were taken for silage - late milk to early dough stage. Where the stage of harvest was grain, the forage was harvested at the same time as the oats were taken for grain yields.

Table 5
Forage and Small Grain Yields in Legume Seeding Establishment - Franklin County
1 9 6 3

Treat. No.	Chemical	Rate/A. lbs. a.i.	Companion crop used	Stage of harvest in relation to oats*	Date of harvest and small grain and forage yields for seeding year - 1963	
					Forage yields tons/A. 15% moisture	Oat yields Bu./A.
1	Check	-	none	silage	2.02	
2	Check	-	oats	grain		75.4
3	Sinox P.E.	1-1/8	none	silage	1.56	
4	Sinox P.E.	1-1/8	none	grain	2.10	
5	Sinox P.E.	1-1/8	oats	silage	2.79	
6	Sinox P.E.	1-1/8	oats	grain		82.6
7	4(2,4-DB) amine	1-1/2	none	silage	1.34	
8	4(2,4-DB) amine	1-1/2	none	grain	1.83	
9	4(2,4-DB) amine	1-1/2	oats	silage	2.70	
10	4(2,4-DB) amine	1-1/2	oats	grain		76.1
11	2,4-D amine	1/4	none	silage	1.21	
12	2,4-D amine	1/4	none	grain	1.64	
13	2,4-D amine	1/4	oats	silage	2.82	
14	2,4-D amine	1/4	oats	grain		71.8
15	4(2,4-DB) + Dalapon	1-1/2 + 2	none	silage	1.40	
16	4(2,4-DB) + Dalapon	1-1/2 + 2	none	grain	1.74	

* Where no companion crop was used, the forage was harvested at the same time as the oats were taken for silage - late milk to early dough stage. Where the stage of harvest was grain, with no companion crop, the forage was harvested at the same time as the oats were taken for grain yields.

Legume establishment was most rapid where the plots were seeded without the companion crop and treated with herbicides. However, the highest total forage yields were obtained from plots seeded with the companion crop and the oats plus the legume-grass harvested as silage.

In Lewis County in 1962 and in Franklin County in 1963, retardation of the growth of the legume-grass seeding, without the companion crop, was least with Dinitro amine, followed by 4(2,4-DB) and was greatest with 2,4-D amine. Visual differences in growth rate were not evident in the St. Lawrence County plots.

The cutting management practice followed in 1962 affected the forage yields in 1963. Plots harvested twice in 1962 gave lower yields in 1963 compared to those harvested only once. This difference is shown in Tables 3 and 4.

A significant visual factor evident in the first harvest of the St. Lawrence County plots in 1963 was the absence of yellow rocket (Barbarea vulgaris) in the dinitro treatments. This was not as marked in the 4(2,4-DB) or 2,4-D treatments.

A summary of the data on botanical separations has not been completed and will be reported at a later date.

Evaluation of Herbicides for Weed Control in Alfalfa - 1963

R. A. Peters and P. E. Keeley^{1/}

Among the herbicides which have shown marked selectivity on legume seedings, the 4-(2,4-dichlorophenoxy) butyric acid derivatives (2,4-DB) are of particular interest. Considerable question still exists as to whether the amine or ester formulation is the most selective on alfalfa at rates giving adequate weed control. There is also limited information on the susceptibility of the various weeds associated with alfalfa.

Since 2,4-DB compounds do little to control annual grassy weeds, continued evaluation of chemicals or mixtures of chemicals controlling grasses as well as broadleaves is needed.

Methods and Materials

The experiment was conducted on the Agronomy Research Farm, Storrs, Connecticut during the 1963 season. Plot size was 21 by 5 feet. The experimental design was a randomized block replicated three times. The soil type was a Faxton fine sandy loam. Fertilization was 1000 lb. of 0-8-12 equivalent per acre.

Vernal alfalfa was seeded on May 10 at 12 lb. per acre. One treatment included a seeding of Gary oats at a rate of $1\frac{1}{2}$ bushels per acre.

Chemical treatments were applied with a compressed air bicycle type sprayer at a rate of 40 gallons of solution per acre. EPTC was applied as a pre-planting treatment the same day as the seeding, May 10. The EPTC was disked in within fifteen minutes after spraying. Pre-emergence treatments were applied on May 14, 1963. Post-emergence treatments were applied on June 12, 1963. At this time alfalfa was in the 2-3 leaf stage, averaging 2 inches tall. The relatively light weed population was predominately of annual grasses. Present were yellow foxtail (Setaria lutescens), large crabgrass (Digitaria sanguinalis), old witch grass (Panicum capillare), and some barnyard grass (Echinochloa crus-galli). The grasses were in the 3-4 leaf stage. Some lambsquarter (Chenopodium album) rough pigweed (Amaranthus retroflexus) and ragweed (Ambrosia artemisiifolia) were also present. The oats were 6-8 inches tall with 2 tillers and 4 leaves on the first culm. The chemicals and the rates used are given in Table I.

Results and Discussion

As rated on July 24, 1963 just prior to cutting, the stand density of alfalfa was 6 or less compared to 8.5 in the check, for the following treatments: oat companion crop, ACP 63-57 3 lb., MCPB ester $\frac{3}{4}$ and MCPB ester $1\frac{1}{2}$ lb. per acre. The 4 lb. of EPTC had a rating of only 7 despite the absence of any weed competition. The thinning from the 4 lb. rate of EPTC was apparent during the entire growing period prior to first cut. Stunting of some plants earlier was outgrown by harvest time. While alfalfa yield reductions, as compared to

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Table 1. Stand Estimates of Alfalfa and Weeds and Yields of Alfalfa -
July 24, 1963

Treatments lb. a.i. or a.e. per acre	Stand density ratings ^{1/}			Alfalfa yields lb. per acre (d.m.)
	Alfalfa	Grassy Weeds	Broadleaf Weeds	
Check	6.3	6.7	2.3	1380 cd ^{2/}
Oats	3.7	7.0	2.7	1175 cd
EPTC 2	8.3	0.0	0.7	2210 abc
EPTC 4	7.0	0.0	1.0	1310 cd
EPTC 2 + 2,4-DB amine $\frac{1}{2}$ ^{3/}	9.7	0.0	0.3	2210 abc
2,4-DB amine $\frac{1}{2}$	7.3	7.3	1.0	1380 cd
2,4-DB amine $\frac{3}{4}$	8.0	5.0	0.0	1660 abcd
2,4-DF amine $1\frac{1}{2}$	8.3	4.7	0.0	2070 abcd
2,4-DB iso-octyl ester $\frac{1}{2}$	7.3	5.7	0.0	2490 a
2,4-DB iso-octyl ester $\frac{3}{4}$	7.0	7.3	0.0	1380 cd
2,4-DF iso-octyl ester $1\frac{1}{2}$	8.0	5.3	0.0	1730 abcd
ACP 63-57 $1\frac{1}{2}$	6.7	5.0	1.7	1450 bed
ACP 63-57 3	6.0	5.7	0.0	1315 cd
Diphenamid + 2,4-DB amine $\frac{1}{2}$	9.0	0.7	0.0	2560 a
Diphenamid 2	9.7	0.0	0.0	2210 abc
Diphenamid 4	8.3	0.0	0.0	1660 abcd
DCPA 2	8.0	4.0	1.0	2420 ab
DCPA 4	9.0	1.3	0.3	2625 a
DCPA 2 + 2,4-DE amine $\frac{1}{2}$	8.3	3.0	0.3	2560 a
Dalapon, Na salt 1 + 2,4-DB amine $\frac{3}{4}$	8.7	1.7	0.0	2695 a
MCPB amine $\frac{3}{4}$	8.0	6.3	0.3	1865 abcd
MCPB amine $1\frac{1}{2}$	6.3	8.0	0.0	1310 cd
MCPB ester $\frac{3}{4}$	5.7	7.3	0.0	1175 cd
MCPB ester $1\frac{1}{2}$	5.0	7.0	0.0	1105 d

^{1/}Ratings on 0-10 scale. 0-no stand, 10-complete cover.

^{2/}Yields followed by the same letter or letters do not differ significantly at the 5% level based on Duncan's multiple range test.

^{3/}2,4-DB amine used is the dimethylamine salt.

the check, were not significant according to the Duncan's multiple range test, the stand density ratings correlate well with the yield data.

The alfalfa and broadleaf weeds were closely observed to determine differences in response due to 2,4-DB formulation and rate. No significant differences were observed in this experiment. There was some tendency for the $1\frac{1}{2}$ lb. rate of the iso-octyl ester to produce more narrow leaflets, termed strap like leaves, than the corresponding amine formulation but this effect did not persist. In a supplemental experiment a comparison was made between 3 lb. of iso-octyl ester and the butyl ester of 2,4-DB. For several days following treatment there was contact injury evident on the plants sprayed with the butyl ester as shown by whitening of the leaflets. This response did not persist nor did it occur at the $1\frac{1}{2}$ lb. rate.

No significant difference in weed kill associated with rate of 2,4-DB could be observed in this or other experiments in Connecticut during 1963. The weed species involved was of more importance than rate. Lambsquarter (Chenopodium album), ragweed (Ambrosia artemisiifolia) and rough pigweed (Amaranthus retroflexus) was controlled by all three rates; $\frac{1}{2}$, $\frac{3}{4}$ and $1\frac{1}{2}$ lb. a.e. per acre. None of these rates gave adequate control of wild radish (Raphanus raphanistrum), winter cress (Barbarea vulgaris), white cockle (Lychnis alba) or shepherd's purse (Capsella bursa-pastoris).

Kill of the sensitive broadleaf weeds was quite slow. Species varied markedly in the type of growth modification and persistence. Lambsquarter was the most susceptible species followed by ragweed. Curvature and thickening of the stem was characteristic of the former while formation of very fine terminal leaves characterized the latter. Pigweed developed enlarged stems at the soil surface and persisted without further growth for several weeks.

While broadleaf weed control in the 2,4-DB plots was satisfactory, the grasses were not controlled. The grasses, released from competition, proliferated thus preventing yield increases over the check. Poor control of grasses was also obtained from the ACP 63-57, DCFA 2 lb. and the MCPFB compounds.

Treatments giving both grassy and broadleaf weed control without injury to alfalfa which resulted in significant yield increases included 2,4-DB amine $\frac{3}{4}$ plus dalapon 1 lb., DCFA 4 lb., DCFA 2 lb. plus 2,4-DB amine $\frac{1}{2}$ lb. and diphenamid 2 lb. plus 2,4-DB amine $\frac{1}{2}$ lb.

Diphenamid and EPTC gave very effective weed control at the higher 4 lb. rate but yield increases were not obtained because of depressive effects on the alfalfa. Both materials caused thinning, as shown by stand density ratings, and initial stunting of some plants. In previous work these rates have not caused such injury. The soil was unusually dry in 1963 at the time of the EPTC pre-plant application with only .56 inches occurring during the previous 10 days. After diphenamid was applied 1 inch of rain fell within 5 days but only .88 inch occurred in the next 13 days. This pattern would suggest that enough rainfall occurred soon after application to carry the diphenamid into the seed germinating zone. Since little dilution followed during the germinating period, greater activity of diphenamid was realized.

Summary

No consistent difference in response of weeds or alfalfa was found in comparing the 2,4-DB amine or iso-octyl ester formulations nor was any obvious difference seen between the $\frac{1}{2}$, $\frac{3}{4}$ or $1\frac{1}{2}$ lb. rates.

The MCPB ester formulation at either the $\frac{3}{4}$ or $1\frac{1}{2}$ lb. rate was quite injurious to the alfalfa as was the $1\frac{1}{2}$ lb. rate of MCPB amine.

Several mixtures were effective in controlling both grassy and broadleaf weeds. Addition of $\frac{1}{2}$ lb. 2,4-DB amine to pre-emergence treatments of 2 lb. diphenamid, 2 lb. DCFA or 2 lb. EPTC pre-plant enhanced broadleaf weed control. The post-emergence application of dalapon plus 2,4-DB amine $\frac{3}{4}$ lb. was also effective. Other experiments at the Storrs Station have indicated that 2 lb. of dalapon in the mixture will result in injury to alfalfa.

Under the dry conditions prevailing in 1963, the 4 lb. rate of EPTC and diphenamid caused injury to alfalfa as reflected in the yields.

A DECADE OF HERBICIDE USE IN VERMONT

A Summary of Ten Years of Spraying for Weed and Insect Control

T. R. Flanagan¹.

The extent of weed and crop-insect control in Vermont has been determined annually since 1953. The data herein have been derived from county agent reports, personal surveys, current census records, and a previous publication.²

Vermont's agricultural acreage is indicated in Figure 1. Almost three million acres, almost half of the total land area of the state, are involved one way or another as farmland. The major portion of this farmland is in pasture. This 43 percent represents 1,273,051 acres of which almost half (555,477 acres) is pastured woodland; unimproved brushy areas with more grass (and rocks) than trees. Another major segment (521,097 acres) of the pasture acreage is represented by unimproved, steep, seepy, wet, brushy "back pasture". Much of this could be improved, often most easily with herbicides. The best pasture land (196,477 acres) is that found on cropland. This latter acreage is included with "cropland" below.

Another aspect of Vermont agriculture is the farmer-owned woodlot, sugar bush and small forest. Annual sales of forest products in excess of \$3,000,000, over 300,000 gallons of maple syrup, and more than 500,000 Christmas trees sold yearly are indicative of the economic importance of this land. This woodland approximates 808,750 acres; some of which has been treated with silvicides and insecticides.

The bulk of the really usable farm land is in hay and plowable cropland. Together with idle cropland in "soil bank", etc., and the pastured cropland mentioned above, this represents about one million acres. This is the land which is farmed most intensively, producing almost \$100,000,000 in annual sales of livestock and livestock products, and almost half that again in value of crops harvested. This land has and will continue to receive the larger proportions of weed and insect pest control treatments.

A closer examination of this cropland (Table 1.) shows that more than half of this million acres of cropland is in hay. It is here that establishment herbicides, and insecticides, can be utilized to advantage. Good pasture accounts for 20%, and about 4% exists as small grain acreage. Seeding time herbicides and spot weed control measures can be used here. Much of the small grain acreage is used as a companion crop for new legume seedings.

Vermont's principal cultivated crop, corn, accounts for less than 5% of the cropland acreage, but more acres of corn are sprayed each year than all other crops combined. Orchards, small fruits, potatoes, legume seed, and nurseries account for less than 1% of the cropland acreage-wise, but represent very economically important segments of farm production. Much of such intensively grown crops should, and do, receive spray treatments.

1. Assistant Agronomist, University of Vermont.
2. Status of Spraying, NEMCC 13:430-439. 1959.

FIGURE 1: VERMONT LAND IN FARMS

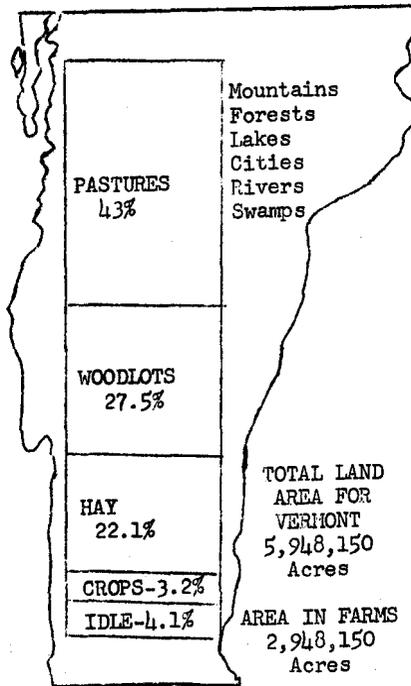
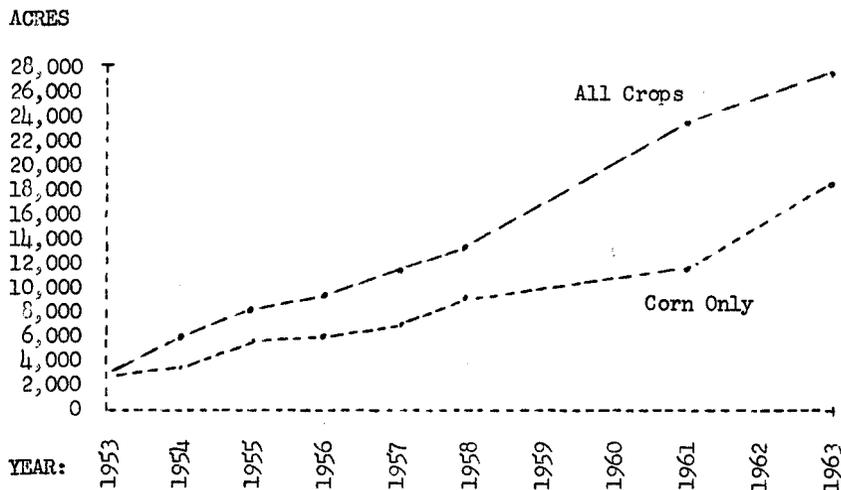


TABLE 1 - PROPORTIONAL USE OF VERMONT CROPLAND

Use	Percent of Total	Acres
Hay	69	652,800
Pasture	21	196,500
Corn	5	46,700
Small grains	4	38,000
All fruits	0.6	5,100
Potatoes	0.2	2,000
Vegetables	0.15	1,500
Nurseries	0.05	400
Total	100.0	943,000

Records and estimates have been kept from 1953 to date, on the acreages of the various crops sprayed, the numbers of sprayers used, extent of custom application and types of pesticides used. Figure 2 indicates the annual trends in overall spray applications for the state. Of the 2392 acres sprayed in 1953 all but 12 acres were herbicides on corn. The subsequent five annual reports show gradual increases in acres of corn sprayed but steadier increases in herbicide use on other cropland.

FIGURE 2: EXTENT OF VERMONT CROPLAND SPRAYED



Total acreage sprayed for crop-weed and insect control with low-pressure, low-volume ground sprayers and aircraft application. High pressure orchard-potato spraying data omitted.

Although corn spraying use increased significantly during the latter half of the decade (Table 2), considerable increases in weed spraying took place in small grain and new seedings, pasture weed control, seed crops, horticultural and nursery crops. (Table 3). The 1961 and 1963 totals on Figure 2 and in Table 2 do not include complete acreage figures for insecticide and fungicide applications. In addition, a few of the county reports are incomplete for crops other than corn. Sufficient data are offered, enabling significance to be ascribed to the rapid increases in crop acreages sprayed of late.

The decline in numbers of farms and total acreage of cropland in use during the decade has been offset by increase in size and value of farms. The average farm has grown from 207 to 243 acres in just the last five years, jumping twenty dollars per acre in value. In addition, more small-acreage horticultural units are in operation. These trends indicate intensified operations, concurrent with increased emphasis on pesticide applications. This is borne out by the spray acreage data presented here.

TABLE 2 - SUMMARY OF SPRAYING IN VERMONT

County	Total acres sprayed each sample year*					
	1953	1954	1956	1958	1961	1963
Addison	40	611	520 [#]	522 [#]	904 [#]	3,750 [#]
Bennington	500	805	600	673	600	780
Caledonia	300	330	1,190	900	1,824	2,607
Chittenden	150	326	1,300	800	1,300+	3,812
Essex	100	430	660	478	300	318
Franklin	100	75 [#]	550	782	600+	711
Grand Isle	22	64	323	452	463	1,235
Lamoille	76	580	300	819	640	470
Orange	300	1,000	665	1,320	750+	1,145
Orleans	75	300	330	735	941	925
Rutland	100	250	1,001	1,415	3,488	3,941
Washington	29	200	475	2,144	2,118	3,076
Windham	250	500	610	400	2,539	1,400
Windsor	350	515	525	908	1,237	2,000
State Total	2,392	5,986	9,049	12,348	22,592	26,170

*All weed and insect spraying on crops, oats, pasture, potatoes, beans, sweet corn, and other horticultural crops except orchards.

[#]Includes both ground and air applications. + Corn acres only.

1961 and 1963 figures do not include all insecticide acres sprayed.

TABLE 3 - 1963 SUMMARY OF ACRES SPRAYED OF VARIOUS CROPS

Weed Control in:	Acres	Other Spraying	Acres
Corn	18,058	Fencerow	2,800*
Small grains	1,300	Farm roadside	767*
New seedings	445	Brush	580
Pasture	795	Silviculture	158
Pasture renovation	30		
Potatoes	930	Insecticides:	
Sweet corn	72	Trefoil	600
Miscellaneous crops	67	Orchards	1,842
Quackgrass control	821	Other crops	1,085

*Acreage figures derived from mileage reports.

The above figures, to show true gains, should be compared with actual acreages of these croplands as farmed in Vermont. The percentage of all cropland acreage as sprayed is shown in Table 4. Percentages also place the counties on a more equitable basis for comparison. Although the acreages sprayed have increased considerably over the last ten years, the proportions of total acreage could well be much greater.

TABLE 4 - PERCENT OF TOTAL CROP ACREAGE SPRAYED FOR WEEDS AND INSECTS*
and PERCENT OF GOAL ATTAINED.

County	1953	1958	1963	Percent of Goal
Addison	0.03	0.37	2.68	10.7
Bennington	1.60	2.05	2.75	11.0
Caledonia	0.41	1.23	2.35	9.4
Chittenden	0.17	0.90	4.36	17.4
Essex	0.48	2.34	2.11	8.4
Franklin	0.08	0.64	0.57	1.3
Grand Isle	0.08	1.73	5.02	20.1
Lamoille	0.18	2.04	1.34	5.4
Orange	0.41	1.81	1.81	7.2
Orleans	0.07	0.68	0.85	3.4
Rutland	0.11	1.51	4.58	18.3
Washington	0.04	3.36	5.50	22.0
Windham	0.62	1.00	3.72	14.9
Windsor	0.46	1.22	2.88	11.5
State Total	0.24	1.24	2.78	11.1

*Percentages based on acreages in Table 1, and acres sprayed, Table 2.

We had suggested earlier an optimum goal of "sprayable" acreage. This, for total farm land would be equivalent to one-fourth of the total cropland acreage. Thus the maximum area of land we might expect to be sprayed annually for weeds, brush and insects would be about 235,000 acres of hay, pasture, and cropland. This goal could be every acre treated once in some way every four years, or conversely, when one out of four acres is being sprayed.

Comparing the actual acreage sprayed in 1963 against this one-quarter "goal" we find that the percent attainment has doubled since 1958 from five to over eleven percent completion.

Yearly totals of corn acreage sprayed (Table 5) show gradual but steady increases in such weed control for most counties, and for the state as a whole. More than 18,000 acres were sprayed in 1963. This represents almost 40% of the total corn acreage. However more than half of Vermont's cornland has been weedy, some fields too weedy to harvest. Somewhat more than half of the cornland to be sprayed represents a "goal" of 24,000 acres. Present accomplishment is good, with 75% of this area sprayed.

The acreages of small grains sprayed have always hidden some acres of new seedings. The total acreages sprayed for small grains and new seedings combined have consistently averaged around 2000 acres for the state each year since 1954. Separate reports for each of these items in 1961 and 1963 indicate that the new seedings (hay crop establishment without companion crop) accounted for one-fourth of these acres sprayed in 1961 and increased to one-third in 1963. The total acreage sprayed is about 5% of the total small grain - new seeding area. No change in the percent attainment "goal" of 22%

is seen, but the shift in herbicide usage could well reflect increased use of the newer seedling establishment herbicides.

TABLE 5 - WEED CONTROL IN CORN*

County	Total Acres Corn:#	1953	1954	1956	1958	1961	1963
Addison	8,864	35	140	180	125	360	1,960
Bennington	2,270	500	600	500	600	600	500
Caledonia	1,702	300	200	500	570	1,100	1,500
Chittenden	6,443	150	225	300	550	1,300	3,500
Essex	123	100	95	250	75	75	148
Franklin	5,584	100	50	450	670	600	500
Grand Isle	2,138	22	40	73	150	170	200
Lamoille	1,468	76	300	250	755	400	300
Orange	2,921	300	800	500	550	750	950
Orleans	1,564	75	200	250	350	700	500
Rutland	5,734	100	250	650	1,200	3,000	3,300
Washington	1,832	17	100	350	1,400	900	2,000
Windham	2,958	250	300	400	300	600	700
Windsor	3,093	350	500	500	900	1,237	2,000
State Total	46,694	2,380	3,800	5,153	8,195	11,792	18,058

*Includes silage corn, grain corn, grazed corn. #Census of 1959.

Additional cropland areas sprayed (Table 3) were too small to be reported in the earlier study. These items were included in the 1961 and current report. Of particular interest is the increased use of herbicides in crop seed production. Figures for trefoil seed are now included. These account for over 500 acres sprayed for quackgrass suppression and much more for insect control. Miscellaneous crops include pop corn, green beans, turf, forest and ornamental nursery stock and horticultural items.

Forest silviculture, roadside and brush control data were excluded from the 1961 and 1963 figures in table 2 and Figure 2. Although these and some county acreage figures for pasture and hay-crop spraying are incomplete, the increases in overall spraying are more than conservative. A fairly safe assumption could be made that the actual acreage sprayed in Vermont is more nearly 50,000 acres than the total 30,475 acres reported (Table 3). If not, such an acreage should shortly be approached, and instead of 11% or 12% of the maximum sprayable acreage being treated, a more realistic appraisal (or projection) would be 20 to 25%. This still leaves considerable room for improvement. Another tenyears should see Vermont well on the way to optimum use of herbicides and other pesticides.

An additional statistic supporting this contention is the doubling of the numbers of weed sprayers in the last five years. From 39 tractor mounted sprayers in 1953, the count increased to 212 in 1958, and today 425 are estimated to be in use. Between 75 and 100 of these are being used in custom work, and over 20 commercial custom applicators are active in the state, including two operating with aircraft. These latter account for several hundred acres of silviculture and brush applications and over 1000 acres of herbicides applied to corn.

HERBICIDAL ACTIVITY OF CHLOROXYURON (N-4(p-CHLOROPHENOXY)-PHENYL-N', N'-DIMETHYLUREA) and C-2059 (N-(3-TRIFLUORO METHYLPHENYL)-N', N'-DIMETHYLUREA) IN SEVEN AREAS OF THE UNITED STATES.

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Introduction

The herbicidal activity of two new substituted urea compounds, chloroxuron and C-2059, was evaluated in tests conducted in seven areas of the United States.

The objective of this study was to evaluate herbicidal effectiveness in widely separated areas simultaneously, therefore pointing up variations in weed control and phytotoxicity to crop plants that may occur when the same herbicide is used on a given crop, but under different climatological conditions.

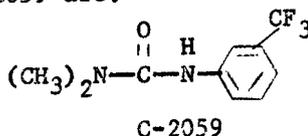
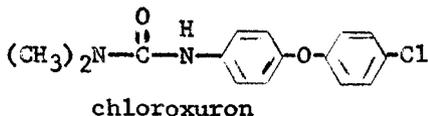
MATERIALS AND METHODS

Chemical, Physical, and Toxicological Properties

Chloroxuron is an odorless, white, crystalline solid with a melting point of 151-152°C and water solubility of 3.7 ppm. The compound is formulated as a 50% wettable powder. The acute oral LD₅₀ of chloroxuron to the mouse is greater than 1000 mg/kg, and to the rat the toxicity value is greater than 3000 mg/kg.

Compound C-2059 is also an odorless, white, crystalline solid and the melting point is 163-164.5°C. The water solubility of C-2059 at 25°C is 60-70 ppm. C-2059 is formulated as an 80% wettable powder. The acute oral LD₅₀ of C-2059 to the mouse is 850 mg/kg and to the rat the LD₅₀ value is over 6000 mg/kg.

The structures of chloroxuron and C-2059 are:



Experimental Plots

Field test plots were located at Alexander City and Dadeville, Ala.; Lubbock, Tex; Elk Grove, Cal.; Hugo, Minn.; Cazenovia, N.Y.; and Vero Beach, Fla. Information regarding soil type, irrigation, temperature and rainfall at the experimental areas is given in Table 1.

Each experimental plot in a test areas was 60'x6' and each State served as a replicate. Plots were planted to a minimum of 5 crops, and each crop row extended the length of the plot. Crops included in the six test areas were cotton, corn, peanuts, soybeans, sorghum, sugar beets, peas, beans, lima beans, oats and wheat. Where possible, the same crops were planted in each test area.

Application Methods

Chloroxuron and C-2059 were applied separately and in combination with other herbicides with a logarithmic sprayer (1) as pre-emergent, incorporated and post-emergent treatments at rates from 0.65 to 23 lbs. active ingredient/acre. Chloroxuron and C-2059 were incorporated into the soil just prior to planting, and the herbicides were mixed with the soil to a depth of two inches with a garden-type rototiller. Pre-emergent applications were made one day after seeding of crops, and post-emergent applications were made 21 days after crops were planted.

Evaluations

Evaluations for plant tolerance and herbicidal activity were made 2, 4 and 6 weeks after pre-emergent and incorporated applications, and 2 and 4 weeks after post-emergent applications. Evaluation stations were located at 5-foot intervals along the 60-foot plot, to ensure that the same dosage rates were evaluated in all test areas. Dosage rates between the 5-foot sampling stations were determined by substituting in the formula (1).

$$\log_{10} C_d = \log_{10} C_o - \log_{10} e \times \frac{vd}{V}$$

where

- d = distance
- C_d = conc. at any distance d
- C_o = original concentration
- v = volume of diluent sprayed
- V = volume of concentrate tank (1 pint)

Crop tolerance and weed control notations were made according to the following arbitrary rating:

- 0 = no effect on crops - no weed control
- 1 = slight chlorosis or burn lesions on foliage - slight effect on weeds

- 2 = all foliage partially burned or chlorotic - ineffective weed control
- 3 = crop plants severely stunted or burned - practical weed control
- 4 = crop foliage all dead, stems green - good weed control
- 5 = crops dead - practically free of weeds

RESULTS AND DISCUSSION

Chloroxuron

Soybeans was the most tolerant crop to pre-emergent, incorporated or post-emergent applications of chloroxuron (Table 2). Sorghum, corn and peanuts were also tolerant to relatively high dosages of chloroxuron in most test areas. This substituted urea was effective against a wide spectrum of broadleaf weed pests, but was not effective against grasses (Table 4).

In these tests chloroxuron was compatible with many commercially available herbicides, and increased weed control, particularly grasses, was achieved with certain mixtures. Mixtures of chloroxuron with various materials in N.Y., Cal., and Minn. did not result in improved weed control; however, there were decided advantages with mixtures in tests conducted in Ala., Fla., and Tex.

In the Alexander City, Ala., test on sandy loam, chloroxuron (4 lb/acre) combined with CDEC (4.5 lb/acre) as a pre-emergent application, was more effective against crabgrass (Digitaria sanguinalis) and cocklebur (Xanthium sp.) than either chemical alone.

When incorporated into the soil, synergistic action was apparent for chloroxuron (4 lb/acre) plus trifluralin (4 lb/acre); lima beans and cotton were tolerant to this combination, and herbicidal activity against crabgrass and cocklebur was decidedly improved. Also, when incorporated into the soil, chloroxuron (4 lb/acre) plus herban (2 lb/acre) resulted in better crabgrass control than either of the materials applied singly; tolerant crops to this mixture were cotton, peanuts, sorghum and lima beans.

On Florida sand pre-emergent application of chloroxuron and diuron combined in an 8:1 or 4:2 ratio in lbs/acre had no effect on cotton or corn, and herbicidal activity against pangolagrass and sedge (Cyperus dentatis) was excellent. Soil incorporation of the mixtures of chloroxuron with DATC in ratios of 8:1, 4:2, or 2:4.5 lbs/acre, respectively, were completely non-phytotoxic to corn, peanuts and cotton, but were completely effective against pangolagrass and sedge.

The test in Texas was conducted on fine sandy loam soil, and pre-emergent application of chloroxuron (2 lb/acre) combined with

herban (0.8 lb/acre) resulted in good control of carelessweed (Amaranthus retroflexus), crabgrass, goathead (Tribulus terrestris) and rye (Lolium sp.), and at the same time was well tolerated by corn, cotton, peanuts and sorghum. Chloroxuron (4 lbs/acre) combined with linuron (1 lb/acre) was well tolerated by peanuts and sorghum, and perfectly controlled carelessweed, crabgrass, goathead and rye.

Compound C-2059

Compound C-2059 is a promising material for post-emergent use on cotton (Table 3). When applied to cotton grown under furrow-type irrigation conditions in Texas and Calif., rates of C-2059 as high as 23 lb/acre were tolerated. In cotton areas of the southeast where rainfall or overhead irrigation provided necessary moisture, cotton was not damaged by rates of C-2059 up to 15 lb/acre. Of the 23 weed species evaluated in these trials (Table 4), 20 were controlled with 4 lb. or less of C-2059. Nutgrass (Cyperus esculentus), Foxtail (Setaria lutescens) and Johnsongrass (Sorghum halepense) required up to 15 lb/acre of C-2059 for adequate control.

Other crops which tolerated dosages of C-2059 above and beyond dosages needed for controlling weed pests were sorghum in Texas and corn and soybeans in California.

In California C-2059, as a pre-emergent herbicide, was tolerated by cotton and corn up to 15 lb/acre while only 2 lb/acre or less were required to kill the weed pests of the area (Table 4).

The incorporation of C-2059 into the soil prior to planting was not encouraging since the margin between dosages for crop tolerance and weed control was too narrow. The test in Cal. was an exception; good weed control was achieved with 2 lb. or less of C-2059, while sorghum and corn were not affected by rates up to 6 and 8 lb., respectively.

In all test areas, C-2059 was applied in combination with commercially available herbicides. In Fla., N.Y. and Cal., the combinations of materials were of no significant advantage over C-2059 for weed control or crop tolerance. Mixtures of C-2059 with other herbicides resulted in improvement in crop tolerance or weed control in tests conducted in Ala., Minn. and Texas.

The combination of C-2059 (4 lb/acre) and CDEC (4.5 lb/acre) as a pre-emergent treatment to cotton in Alexander City, Ala., on sandy loam soil, appeared promising from the standpoint of improved crop tolerance and increased herbicidal activity of the combination when compared with either material alone. Also, there was improved crop tolerance of C-2059 - 4 lb/acre, + CDAA - 4.5 lb/acre, to blackeyed peas, and C-2059 - 4 lb/acre, + dacthal - 10 lb/acre, to cotton.

The test at Dadeville, Ala., was conducted on clay loam soil and the

results were different from the results obtained on sandy loam soil at Alexander City, Ala.

The combination of C-2059 (4 lb/acre) and chloroxuron (4 lb/acre) as a pre-emergent application resulted in marked increase in tolerance of peanuts, and slightly better control of broadleaves than when either material was applied alone. This same combination was much more phytotoxic to lima beans than either compound alone. Also, as a pre-emergent, C-2059 at 4 lb/acre plus herban at 2 lb/acre resulted in improved broadleaf weed control, and was adequately tolerated by corn, peanuts, blackeyed peas, cotton and sorghum. However, this combination of materials was quite phytotoxic to soybeans and lima beans. The mixture of C-2059 (4 lb/acre) and atrazine (5 lb/acre), as a post-emergent herbicide, was safe on corn and soybeans, and weed control was improved over the performance of either compound alone. Practical control of Johnsongrass was achieved with this mixture, in addition to excellent control of coffeeweed (Triosteum perfoliatum) and both varieties of morning glory (Ipomoea purpurea and Thyella tammifolia).

Certain combinations of C-2059 with other materials incorporated into the soil were of interest in Minn. on loam soil. The combination of C-2059 (4 lb/acre) with endothal (5 lb/acre) was tolerated by sugar beets and effective foxtail and pigweed (Amaranthus retroflexus) control was obtained. Quackgrass (Agropyron repens) and nutgrass were resistant to the C-2059 + endothal combination.

Pre-emergent application of C-2059 (4 lb/acre) combined with chloroxuron (4 lb/acre) on Texas fine sandy loam was tolerated by cotton and sorghum, while controlling carelessweed, crabgrass, goathead and rye. C-2059 (4 lb/acre) combined with CIPC (10 lb/acre) was tolerated by cotton and greatly increased the effectiveness of each herbicide against carelessweed, crabgrass, goathead and rye.

SUMMARY

Chloroxuron is a new substituted urea that controls many broadleaf weed species, and has a wide safety margin on soybeans, peanuts and certain vegetable crops, depending upon the method of application. Chloroxuron was not effective against grasses, but combinations of chloroxuron with commercially available herbicides were effective against both broadleaf and grasses without decreasing crop tolerance.

Compound C-2059 as a post-emergent application was particularly promising on cotton. C-2059 was highly effective against most broadleaf weeds and grasses at dosage levels well below those tolerated by cotton.

The tolerance of other crops to C-2059 was often favorable, depending

upon method of application, soil type and rainfall. Certain combinations of C-2059 with other herbicides were also promising.

LITERATURE CITED

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TABLE 1

GEOGRAPHICAL AND PHYSICAL DATA AT SEVEN HERBICIDE TESTING LOCATIONS THROUGHOUT THE U. S.

LOCATION	SOIL TYPE	IRRIGATION TYPE	AIR TEMP (F) (AVE. HIGH)	SOIL TEMP (F) (AVE. HIGH)	TOTAL RAINFALL (INCHES)
Alexander City, Ala.	sandy loam	none	93	95	4.5
Dadeville, Ala.	clay loam	none	88	90	2.6
Elk Grove, Calif.	San Joaquin sandy loam	furrow	94	--	(Furrow irrigated as needed)
Vero Beach, Fla.	sand	overhead	92	95	4.2 (3.0 overhead irrigation)
Hugo, Minn.	loam	none	80	86	4.11
Cazenovia, N.Y.	loam	none	85	88	7.6
Lubbock, Tex.	fine sandy loam	furrow	86	84	3.71

TABLE 2

MAXIMUM RATE OF ACTIVE INGREDIENT/ACRE OF CHLOROXYURON TOLERATED BY
CROPS AT SEVERAL LOCATIONS THROUGHOUT THE UNITED STATES

LOCATION AND METHOD OF APPLICA- TION*	COTTON	CORN	BORGHUM	SOYBEANS	PEANUTS	SNAP BEANS	LIMA BEANS	BLACKEYED PEAS BEETS	SUGARBETTS	OATS	WHEAT	PEAS
<u>Ala.</u>												
Pre	4	23	4	23	15		3	3				
Inc	4	23	15	23	10		23	23				
Po	0.65	2	3	23	3		4	2				
<u>Calif.</u>												
Pre	23	23	23	23	23				23			
Inc	3	3	23	23	23				2			
Po	15	23	23	23	23				0.65			
<u>Fla.</u>												
Pre	4	23	23		23							
Inc	15	23	--		23							
Po	7	4	23		4							
<u>Minn.</u>												
Pre		6	6	23		0.65			0.65	3	1	23
Inc		23	23	23		15			0.65	15	23	23
Po		6	12	23		0.65			0.65	15	3	12
<u>N. Y.</u>												
Pre		23	23			12		0.65				
Inc		23	23			15		6				
Po		23	23			2		0.65				
<u>Tex.</u>												
Pre	15	3	11		23							
Inc	6	6	3		23							
Po	0.65	23	23		15							
*Pre	- pre-emergent											
Inc	- incorporated											
Po	- post-emergent											

TABLE 3

MAXIMUM RATE OF ACTIVE INGREDIENT/ACRE OF C-2059 TOLERATED BY
CROPS AT SEVERAL LOCATIONS THROUGHOUT THE UNITED STATES

LOCATION, AND METHOD OF APPLICA- TION *	COTTON	CORN	SORGHUM	SOYBEANS	PEANUTS	SNAP BEANS	LIMA BEANS	BLACKEYED PEAS	BETS	SUGARBETS	OATS	WHEAT	PEAS
<u>Ala.</u>													
Pre	2	1	1	1	0.65		2	0.65					
Inc	4	5	3	3	2		3	3					
Po	8	2	3	1	2		3	2					
<u>Calif.</u>													
Pre	15	6	6	2	4					1			
Inc	1	8	6	0.65	4					0.65			
Po	23	15	11	3	3					1			
<u>Fla.</u>													
Pre	23	4	4		4								
Inc	6	3	-		2								
Po	15	3	5		4								
<u>Minn.</u>													
Pre		3	2	0.65		0.65				0.65	0.65	0.65	3
Inc		4	6	3		1				0.65	1	0.65	3
Po		3	8	1		1				2	1	1	8
<u>N. Y.</u>													
Pre		5	4			1		0.65					
Inc		2	6			0.65		1					
Po		3	3			1		0.65					
<u>Tex.</u>													
Pre	4	2	23		1								
Inc	11	0.65	23		23								
Po	23	4	11		0.65								

*Pre - pre-emergent
Inc - incorporated
Po - post-emergent

TABLE 4

SUMMARY OF HERBICIDAL EFFECTIVENESS INDICATING THE LOWEST RATE (ACTIVE INGREDIENT/ACRE) OF CHLOROKURON AND C-2059 GIVING EFFECTIVE WEED CONTROL, AND THE METHODS OF APPLICATION FOR MAXIMUM HERBICIDAL ACTIVITY

LOCATION AND WEED SPECIES	APPLICATION		APPLICATION	
	C-2059	METHOD*	CHLOROKURON	METHOD*
<u>Alabama -</u>				
Coffeeweed	0.65	po	3	po
Common morning glory	0.65	pre - inc	1	po
Small flowered morning glory	0.65	inc - po	3	inc
Johnsongrass	15	po	23	pre - inc - po
Cocklebur	0.65	pre - inc - po	1	po
Horsenettle	4	po	1	po
<u>California -</u>				
Tumbleweed	0.65	pre - inc - po	0.65	po
Lovegrass	1	inc	23	inc - po
Barnyardgrass	3	po	23	po
<u>Florida -</u>				
Pangolagrass	3	pre - inc	12	inc
Sedge	0.65	pre - po	0.65	pre
<u>Minnesota -</u>				
Quackgrass	6	pre - inc	23	pre - inc - po
Nutgrass	4	pre	12	pre
Foxtail	0.65	inc	6	inc
Pigweed	0.65	pre - inc	0.65	pre - inc
<u>New York -</u>				
Lambsquarter	0.65	pre - inc - po	2	po
Mustard	0.65	pre - inc - po	0.65	pre - po
Dandelion	0.65	pre - inc - po	3	po
Clumpedgrass	2	pre - inc	6	inc
Buttercup	0.65	pre - inc - po	1	po
<u>Texas -</u>				
Carelessweed	0.65	po	6	po
Goathead	2	inc	0.65	po
Rye	0.65	po	4	inc
Crabgrass	2	po	3	po

*pre - pre-emergent
 inc - incorporated
 po - post-emergent

EFFECT OF FORMULATION, RATE AND SOIL
MOISTURE ON ATRAZINE PERSISTENCE¹

by

H. P. Wilson and R. H. Cole²

Although herbicides have many benefits, they can create some problems. One of the more important problems is the persistence of herbicides in soils. The purpose of this investigation was to determine the persistence of two rates of liquid and granular 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (Atrazine) under three levels of soil moisture.

Procedure

During November 1962, preliminary greenhouse studies showed that a mixture of equal amounts of a Matapeake silt loam soil and sand would permit good water percolation while still retaining enough water to maintain plant growth for several days. Based on this preliminary data, three water rates were established as follows:

- I - watered to field capacity daily,
- II - watered to field capacity every 3 1/2 days,
- III - watered to field capacity once each week.

Pots were brought to field capacity by weight.

Oats were planted in 8-inch plastic pots on December 3, 1962. Liquid and granular Atrazine were applied to the soil surface at rates of 3 and 6 pounds per acre. The liquid used was an 80 percent wettable powder and the granular was a 10 percent granular on an ammonium sulfate carrier. The amount

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Research conducted as a Senior Research Problem.

of water needed to bring the soil to field capacity was applied at the surface. There were two replications.

On January 7, 1963, the percent of oats killed in each treatment was determined and each was given a rating between 1 and 5, 1 representing no kill and 5 representing complete kill. The pots were then replanted to oats and the same water schedule was again followed. This procedure was repeated on February 11, 1963, April 1, 1963, and May 6, 1963. On June 10, 1963 the treatments were rated for the final time and the test was discontinued.

Results and Discussion

Table 1 shows the rate of kill obtained from each major factor included in the investigation. There was no difference between Atrazine rates in the first two runs. However, in runs 3, 4 and 5 rates were significantly different with the 6 pound rate giving more kill than the 3 pound rate. Granular Atrazine was more persistent in the soil than was the liquid. This became evident in run 3 and the differences were significant in runs 4 and 5. Water rates also had a significant effect on Atrazine persistence. Atrazine persistence increased as the water rate decreased. Differences of this type were expected a priori.

The interaction between rates and formulations was statistically significant. Granular Atrazine was more persistent than the liquid at both rates. The persistence of the granular was much greater at the 6 pound rate than at the lower 3 pound rate. This is shown in table 2. A significant interaction was also found between Atrazine rates and water levels. Greater differences in persistence among water levels were observed at the 6 pound rate than were found at the 3 pound rate (table 2).

This would indicate that when maximum differences are desired between liquid and granular materials, tests should be conducted at high Atrazine rates. On the other hand, if maximum differences between rates of Atrazine were desired, tests should be conducted at the lowest water level that will adequately support plant growth.

No interaction was observed between water levels and formulations. These results would indicate that future tests

could be conducted at a single moisture level. The lowest water level would be preferred to maximize differences.

Summary

An investigation was conducted to determine if rate of application, formulation and moisture level had any effect on the persistence of Atrazine. The results obtained indicate that all three variables had an effect on persistence of the herbicide. Two interesting interactions, (Rates x Formulations) and (Rates x Water Levels), were found significant. There was no significant interaction between formulations and water levels. The implications of these findings were discussed.

Acknowledgements

The authors wish to acknowledge the assistance of the Geigy Chemical Corporation in making available the materials used in these tests and thank them for their continued interest in this work.

Table 1. Ratings of percent kill of oats from different herbicide rates, formulations and water rates.¹

Atrazine Rate	1	2	<u>Run</u> 3	4	5
3 lbs.	5.0	5.0	3.7	2.0	1.6
6 lbs.	5.0	5.0	4.9	3.6	3.1
F Value	N.S.	N.S.	14.09** ²	358.10**	64.29**
<u>Formulation</u>					
Liquid	5.0	5.0	4.2	2.3	2.0
Granular	5.0	5.0	4.4	3.2	2.7
F Value	N.S.	N.S.	N.S.	120.00**	12.67**
<u>Water Rate</u> ³					
I	5.0	5.0	3.9	2.0	1.2
II	5.0	5.0	4.2	2.9	2.5
III	5.0	5.0	4.8	3.5	3.2
F. Value	N.S.	N.S.	N.S.	108.10**	38.86**

1. Scale: 1 = no injury;
2 = slight injury - up to 10% kill;
3 = moderate injury - 11% to 40% kill;
4 = severe injury - 41% - 99% kill;
5 = 100% kill
2. Significant at the .01 level
3. I - Raised to field capacity daily
II - Raised to field capacity every 3 1/2 days
III - Raised to field capacity once each week

Table 2. Ratings of percent kill of oats of two important interactions¹Atrazine Rate x Formulation Interaction:
Formulation

Atrazine Rate	<u>Run 4</u>		<u>Run 5</u>	
	Liquid	Granular	Liquid	Granular
3 lbs.	1.7	2.3	1.5	1.7
6 lbs.	3.0	4.2	2.5	3.7
<u>E Value</u>	9.05* ²		7.10*	

Atrazine Rate x Water Rate Interaction

Atrazine Rate	<u>Water</u>			<u>Rate</u> ³		
	<u>Run 4</u>			<u>Run 5</u>		
	I	II	III	I	II	III
3 lbs.	1.5	2.0	2.5	1.0	1.8	2.0
6 lbs.	2.5	3.8	4.5	1.5	3.2	4.5
<u>F Value</u>	13.10** ⁴			9.52**		

- Scale: 1 = no injury;
2 = slight injury - up to 10% kill;
3 = moderate injury - 11% to 40% kill;
4 = severe injury - 41% - 99% kill;
5 = 100% kill
- Significant at the .05 level
- I - Raised to field capacity daily
II - Raised to field capacity every 3 1/2 days
III - Raised to field capacity once each week
- Significant at the .01 level

EFFECTS OF GRANULAR ATRAZINE FORMULATION ON WEED CONTROL AND PERSISTENCE¹

by

H. Kuratle and R. H. Cole²

What formulation of granular Atrazine, 2-chloro-4, ethyl-amino 6, isopropyl - amino - s - triazine, should be used to get the best weed control with the least amount of persistence? To help answer this question greenhouse studies were conducted to test several formulations. The factors investigated were carrier, percent active ingredient, herbicide rate, and soil type.

Procedure

The experiment was planted on November 16, 1962 in the Agronomy greenhouse at the University of Delaware. Each replication consisted of forty-four three inch pots. Half of the pots were filled with a fine textured soil (Elkton clay loam) and half with a coarse textured soil (Lakeland loamy sand). After filling, all pots were placed in a metal tray containing washed sand. The pots were imbedded in the sand to insure uniform drainage. Each pot was saturated with water and allowed to drain to field capacity before planting. Subsequent watering maintained all pots at a uniform water level. All pots were seeded with a mixture of rape, Brassica napus, and German millet, Setaria italica. Rape was used as a typical broadleaf and German millet a typical annual grass.

The herbicide, granular Atrazine, was applied pre-emergence immediately after seeding. Treatments were as follows:

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 2. Research Fellow (Horticultural Dept.) and Assistant Professor of Agronomy. Previously submitted as undergraduate thesis for Degree with Distinction at the University of Delaware, Newark, Delaware.

Carrier:

1. Attaclay (insoluble)
2. Ammonium sulfate (soluble)

Percent active ingredient:

1. 4% on attaclay carrier
2. 8% on attaclay carrier
3. 10% on ammonium sulfate carrier
4. 20% on ammonium sulfate carrier

Rate:

1-5 Rates ranged from 1 lb./acre to 5 lbs./acre

Check:

Two untreated pots of each soil type were included in each replication.

Both soil types received identical treatments. Treatments were replicated five times.

After a four week growing period all the remaining green foliage was cut off and weighed to determine percent weed control. For persistence studies the surface soil was worked equivalent to rototilling, and all pots were seeded to oats, Avena sativa. Oats were used as an indicator crop since they are very susceptible to Atrazine injury. The length of growing period was extended from four to five weeks. All pots were harvested in the previously described manner.

Results and Discussion

The results of these tests were as follows:

1. All rates gave excellent control of rape while better control of German millet was obtained as rates increased (table 1).
2. The soluble carrier, ammonium sulfate, was superior regardless of soil or concentration (table 2). This is thought to be due primarily to carrier solubility.

Lakeland loamy sand, (table 2) probably due to reduced water movement in the fine textured soil and herbicide adsorption on the surface of the colloidal particles.

4. Regardless of carrier the fine textured Elkton clay loam showed the most persistence (table 3) further indicating the possibility of herbicide adsorption on the surface of the colloidal particles.
5. More persistence was shown using the soluble carrier, ammonium sulfate (table 3).
6. Table 4 indicates more persistence with the higher herbicide concentration.

Summary

Several formulations of granular Atrazine were tested in the greenhouse to help answer the question, what formulation of granular Atrazine should be used to get the best weed control with the least amount of persistence. The factors studied were carrier, percent active ingredient, herbicide rate, and soil type.

The best weed control was obtained on the Lakeland soil regardless of carrier, while on any one soil the ammonium sulfate carrier was superior. All rates gave excellent control of rape while better control of German millet was obtained as rates increased.

As measured by weed control activity, the greatest persistence occurred on the Elkton clay loam soil. Of the two carriers and four concentration tested the ammonium sulfate carrier and higher concentration appeared to be the most persistent.

Results of this experiment indicate no obvious way of obtaining good weed control plus limited persistence. The only alternative is to strive for good weed control in those crops that give high returns and use proper rotation to compensate for persistence.

Acknowledgement

The authors wish to acknowledge the Giegy Chemical Corporation in making available the materials used in these tests and thank them for their continued interest in this work.

Table 1 Comparison of Five Rates of Granular Atrazine for Weed Control

Rates (lbs./acre)	Percent weed control as indicated by green wt. of millet and rape 4 weeks after herbicide application.	
	<u>Millet</u> ¹	<u>Rape</u> ¹
1	59%	100%
2	65%	100%
3	70%	100%
4	76%	100%
5	84%	100%
Average	71%	100%
LSD .05	14%	

1. Averages for 5 reps., 2 concs., 2 soils, and 2 carriers.

F Value: Rates = 3.97**

Table 2. Comparison of Two Carriers of Granular Atrazine for Weed Control at Two Concentrations and on Two Soil Types

Carrier	Percent weed control of grass as indicated by green wt. of millet 4 weeks after herbicide application					
	<u>Soils</u> ¹			<u>Concentrations</u> ²		
	Lakeland Loamy sand	Elkton Clay loam	Ave.	high ³	low ⁴	Ave.
Attaclay (insol.)	92%	84%	88%	68%	60%	64%
Amm. sul. (sol.)	96%	90%	93%	78%	78%	78%
Average	94%	87%		70%	69%	

1. Averages for 5 rates, 5 reps., and 2 concentrations.
2. Averages for 5 rates, 5 reps., and 2 soils
3. 8-G on attaclay plus 20G on ammonium sulfate
4. 4-G on attaclay plus 10-G on ammonium sulfate

F values: Soils = 101.96** Concentration = N.S.
 Carriers = 10.14** Carriers x Concentration = N.S.
 Soil x Carriers = 4.46*

Table 3. Comparison of Two Carriers of Granular Atrazine for Persistence on Two Soil Types

Percent kill as indicated by green wt. of oats 5 weeks after seeding.

<u>Carrier</u>	<u>Soils</u> ¹		<u>Ave.</u>
	<u>Lakeland loamy sand</u>	<u>Elkton clay loam</u>	
Attaclay (insol.)	31%	65.7%	48.4%
Ammonium sulfate (sol.)	49%	66.3%	57.6%
Ave.	40%	66 %	

1. Average for 5 rates, 5 reps., and 2 concentrations

F values: Soils = 17.14**

Carriers = 3.14 (P = .10 level)

Soils x Carriers = 2.87 (P = .10 level)

Table 4. Comparison of Two Concentrations of Granular Atrazine for Persistence

Percent kill as indicated by green wt. of oats 5 weeks after seeding.¹

<u>% Concentration</u>	
Low ²	27%
High ³	40%
Ave.	33.35%

1. Averages for 5 reps., 5 rates, 2 soils, and 2 carriers..

2. 4-G on attaclay plus 10-G on ammonium sulfate.

3. 8-G on attaclay plus 20-G on ammonium sulfate.

F. value: Concentration = 3.24 (P = .10 level)

COMPARISON OF SPRAY AND GRANULAR FORMULATIONS
OF SEVERAL HERBICIDES, 1960 - 1963¹

by R. W. Feeny and R. H. Cole²

The object of these tests was to compare the effectiveness of spray and granular formulations of thirteen herbicides. Weed control obtained from liquid and granular formulations has been the subject of many investigations. There are those who have reported that the granular is equal and often superior to the liquid carrier. Among these are Danielson, (1) and Sweet et al. (2). On the other hand, Schuldt et al. (3) and Springer and Cole state that many times the granular carrier may, under certain conditions, be inferior to the spray form of the herbicide.(4). This report will concern itself with the field comparison of several herbicides tested in both the liquid and granular form.

Procedure and Results

Test were conducted from 1960 to 1963. Some of the herbicides were tested over a period of two to three years. All studies were conducted at the University of Delaware Research Farm, Newark, Delaware and the University Substation Division Farm in Georgetown, Delaware. The predominant soil type in Newark is Matapeake silt loam, while the major soil type in Georgetown is Norfolk sandy loam. In all years, the granular material was applied by hand, except 1962 when a Gandy granular field applicator was used. The liquid material was sprayed with a bicycle sprayer in 1960-1961 and with a hand CO₂ sprayer in 1962-1963. All material was applied pre-emergence within twenty-four hours after planting. Care was taken in all years to assure even and accurate distribution of the herbicide over the test plot.

Ratings of crop injury, broadleaf, and grass weed control

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1. Published as Misc. Paper No. 457. Contribution from the Department of Agronomy with the approval of the Director of the Agricultural Experiment Station, University of Dealware, Newark, Delaware.
 2. Graduate Assistant and Assistant Professor of Agronomy, Respectively.

were taken early in the season. This date was between the third and fourth week after planting. The predominant weed species in the test plots were: pigweed (Amaranthus retroflexus); ragweed (Ambrosia artemisiifolia); lamb's quarter (Chenopodium album); foxtail species (Setaria sp.); crabgrass (Digitaria sanguinalis); and goosegrass (Eleusine indica). All plots received minimum tillage which was one or two cultivations. The last cultivation was usually at lay-by.

Table I lists the herbicides used, the number of locations, and the crop in which weed control and injury ratings were recorded. Table II gives the herbicide, the year tested, effectiveness as a grass and broadleaf herbicide, as well as yield differences and crop injury. Each herbicide rating is divided into its liquid and granular performance. The herbicides are listed in a relative solubility order. The volatile materials are listed first, followed by the less soluble materials, and last by the rather insoluble materials. The same amount of active material, for a given herbicide, was applied in the liquid and granular form.

Discussion and Summary

The performance of thirteen herbicides in the liquid and granular form has been reported, as indicated by field tests from 1960 to 1963 at the University of Delaware Research Farms. The results are summarized and reported in tabular form which appears in Table II.

It can be seen from table II that the liquid formulation gave better results in a greater number of tests than did the granular carrier. As the solubility of the herbicides decreased, the liquid formulation became superior to the granular. Except for one test, the performance of the granular was better than that of the liquid only with those herbicides that depend on their volatility for their phytotoxic effect. This has been reported by Antoginini (5). Other than these volatile materials, it seems that as the solubility of the herbicide decreases its performance as a granular decreases.

Investigations concerning plant uptake as related to liquid and granular solubility should be considered in future formulation studies. Work in this field may help to answer many of the questions concerning liquid and granular perform-

Table I. Herbicides Tested, Crop, and Number of Test Locations

<u>Herbicide Tested</u>	<u>Crop</u>	<u>Number of Locations</u>
<u>1960</u>		
2,4-D	corn	2
CDAА-T	corn	2
CDAА	corn	2
CDAА	soybeans	2
2,4-D	soybeans	2
<u>1961</u>		
Atrazine	corn	1
CDAА-T	corn	1
EPTC	corn	1
2,4-D	corn	1
DNBP	soybeans	2
Amiben	soybeans	2
Zytron	soybeans	2
Tillam	soybeans	2
Diphenamid	soybeans	2
Na PCP	soybeans	2
<u>1962</u>		
Atrazine	corn	1
R 1607	corn	1
DNBP	corn	1
Amiben	soybeans	1
<u>1963</u>		
Atrazine	corn	3
Simazine	corn	3
R 1607	corn	3
EPTC	corn	3
DNBP	corn	3
Na PCP	corn	3

Table II. Liquid and Granular Effectiveness of Thirteen Herbicides

Herbicide	Year Tested	Test Crop	Broadleaf Weed Control		Grass Weed Control		Crop Yield		Crop Injury	
			Liquid Superior No Sig. Difference	Granular Superior	Liquid Superior No Sig. Difference	Granular Superior	Liquid Superior No Sig. Difference	Granular Superior Sig. greater with granular No. Sig. Difference		
EPTC	1961	corn		x	x		x		x	
	1963	corn	x		x		x		x	
Tillam	1961	soybeans	x		x		x		x	
R 1607	1962	corn	x		x		x		x	
	1963	corn	x			x	x		x	
2,4-D	1960	corn		x		x	x		x	
	1960	soybeans	x			x	x		x	
	1961	corn		x		x	x		x	
DNBP	1961	soybeans	x		x		x		x	
	1962	corn	x		x		x		x	
	1963	corn	x		x		x		x	
NaPCP	1961	soybeans	x		x		x		x	
	1963	corn		x		x	x		x	
CDA A	1960	corn	x		x		x		x	
	1960	soybeans		x		x	x		x	
Zytron	1961	soybeans	x		x		x		x	
Amiben	1961	soybeans	x		x		x		x	
	1962	soybeans	x		x		x		x	
CDA A-T	1960	corn	x			x	x		x	
	1961	corn	x		x		x		x	
Diphenamid	1961	soybeans	x		x		x		x	
Atrazine	1961	corn	x		x		x		x	
	1962	corn	x		x		x		x	
	1963	corn		x		x	x		x	
Simizine	1963	corn	x		x		x		x	

Acknowledgement

The authors wish to acknowledge the assistance of the herbicide manufactures in making available the materials used in these tests and thank them for their continued interest in this work.

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Preliminary Results on Control of
Wild Garlic (Allium vineale) In Grass Meadows

Armin H. Furrer, Jr.^{1/}

Introduction

Wild garlic (Allium vineale L.) infestations are continuing to spread in winter wheat, pastures, and meadows. The problem is becoming particularly serious in the winter wheat areas of the Central Plains Region in Western New York. Frequent cultural operations tend to spread the underground bulbs. Planting wheat seed containing aerial bulblets is another common method of dispersal. Losses are due primarily to the dockage on the price of wheat paid to the farmer and to off-flavors and odors produced in milk.

The ester formulation of 2,4-D has been the standard recommendation for control. With the rapid introduction of new herbicides, this study was initiated in 1962 to evaluate their effectiveness.

Materials and Methods

On May 11, 1962, 22 chemical treatments (Table 1) were applied on an old alfalfa meadow in 4 replications. The stand of wild garlic averaged 5 to 6 plants per sq. ft. and 7 to 9 inches in height. The individual plot size was 6 by 24 feet.

Observations were made on May 29, 1962 and April 10, 1963. On the basis of these observations, the most promising plots were re-treated on April 16, 1963 (see Table 1). In addition, these chemicals were applied on a new area in the same field in 4 replications (Table 2). Wild garlic averaged 7 to 9 inches tall at the time of treatment.

Observations were made on May 21, June 20, and Sept. 27, 1963.

Results and Discussion

Observation ratings were made on the following basis:

10 = complete control of topgrowth; 0 = no control of topgrowth.

Because many of the treatments were comparable in degree of control, they have been grouped in order of effectiveness. Table 3 is a summary of results for the area treated in 1962 and 1963 and of the treatments applied in 1963 only.

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Table 2
Control of Wild Garlic in Grass Meadows - Block II
Treatments Applied in 1963

Treatment No.	Chemical	Rate a.i. lb/A 4-16-63
1	2,4-D ester	1.0
2	2,4-D ester	2.0
3	2,4-D acid	1.0
4	2,4-D acid	2.0
5	Dicamba	1.0
6	Dicamba	2.0
7	Dicamba	3.0
8	Emulsamine E-3	1.0
9	Emulsamine E-3	2.0
10	Amitrole-T	2.0
11	Amitrole-T	4.0
12	Check	0.0

Table 3
Wild Garlic Control Ratings

Group 1 Rating*		Group 2 Rating		Group 3 Rating	
10 to 9+		9		8	
Chemical	Rate a.i. lb./A.	Chemical	Rate a.i. lb./A.	Chemical	Rate a.i. lb./A.
<u>Block I. 1962 - 1963</u>					
2,4-D ester	2+2	Emulsamine	1+1	Dicamba	1+1
2,4-D ester	1+1	E-3			
2,4-D acid	2+2	2,4-D acid	1+1		
Dicamba	3+3				
Dicamba	2+2				
Emulsemine E-3	2+2				
<u>Block II. 1963</u>					
None		2,4-D ester	2	Emulsemine	2
		2,4-D acid	2	E-3	
		Dicamba	3		
		2,4-D ester	1		

* 10 = complete control of topgrowth.
0 = no control of topgrowth.

Table 1

Control of Wild Garlic in Grass Meadows - Block I
Treatments Applied in 1962 and 1963

Treatment No.	Chemical	Rate a.i. lb/A	
		5-11-62	4-16-63
1	2,4-D ester	1.0	1.0
2	2,4-D ester	2.0	2.0
3	2,4-D acid	1.0	1.0
4	2,4-D acid	2.0	2.0
5	Silvex ester	1.0	---
6	Silvex ester	2.0	---
7	Dicamba	1.0	1.0
8	Dicamba	2.0	2.0
9	Dicamba	3.0	3.0
10	Linuron	1.0	---
11	Linuron	2.0	---
12	Linuron	3.0	---
13	Emulsamine E-3	1.0	1.0
14	Emulsamine E-3	2.0	2.0
15	Kurosals SL	1.0	---
16	Kurosals SL	2.0	---
17	2,4-D propionic	1.0	---
18	2,4-D propionic	2.0	---
19	Amitrole-T	4.0	2.0
20	2,4,5-T ester	1.0	---
21	2,4,5-T ester	2.0	---
22	Check	0.0	0.0

In the area treated in 1962 and 1963, Amitrole-T, 2,4,5-T ester, and Silvex ester resulted in fair to poor control of wild garlic. Linuron, Kurosals-SL, and 2,4-D propionic were ineffective.

In the area treated in 1963 only, Emulsamine E-3 and 2,4-D acid at rates of 1 pound per acre, Dicamba at 2 pounds per acre, and Amitrole-T at 4 pounds per acre gave fair control of wild garlic. Amitrole-T at 2 pounds was poor.

Based on these results, the following chemicals resulted in very good to excellent control of wild garlic in grass meadows at rates of 1 to 2 pounds per acre as repeat treatments applied in early spring: 2,4-D ester, 2,4-D acid, and Emulsamine E-3. Dicamba required rates of 2 to 3 pounds per acre for comparable control.

Thus far, the newer herbicides show no advantage over 2,4-D ester. The effects of these herbicides on the underground bulbs is not known.

A STUDY OF THE EFFECTS OF NITROGEN
ON THE GROWTH OF ANTHEMIS SPP.

J. F. Ellis and R. D. Ilnicki¹

Dog fennel (Anthemis cotula) and corn chamomile (A. arvensis) are winter annual weeds which cause serious losses in small grain production, and they are also pests in other crops and pastures in the Northeastern States. These species produce great quantities of seed which apparently germinate throughout most of the growing season. Because of these extensive germination periods there is increased difficulty in developing control practices.

Very little is known of the growth habits under various environmental and ecological conditions.

The objective of this experiment was to study the effects of three levels of nitrogen on the growth and reproductive capacities of corn chamomile (A. arvensis).

Literature Review

Kraus and Kraybill (3) experimented with nitrogen nutrition in the control of flowering and fruiting of tomato. They found that high nitrogen applications favored luxuriant vegetative growth but little reproductive development. The work of Wittwer and Teubner (5) contradict these results. They found the highest nitrogen level used gave the best flowering. El Hinnawy (2) and Eguchi (1) observed similar results with other plant species.

Materials and Methods

The experiment was designed as a completely randomized block with three treatments and four replications. This experiment was conducted in a greenhouse at the Agricultural Experiment Station of Rutgers * The State University, New Brunswick, New Jersey.

The treatments consisted of three levels of nitrogen: 140, 42, and 14 parts per million. The nutrient solutions were prepared according to Shive and Robbins (4).

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Nine-inch, glazed, slant-bottom crocks were filled with washed sand. Uniform corn chamomile seedlings with five fully expanded leaves were transplanted to the crocks on April 29, 1963; a single plant to a crock. A supplementary nutrient solution was added to the crocks until the plants became vigorous. Treatments were initiated on May 28, 1963 when the average tiller length was eight centimeters. The solutions were added daily.

Growth measurements were made at various time intervals. The initial flowering dates of each treatment were recorded. The plants were observed carefully for any nutrient deficiency symptoms or morphological abnormalities. Mature flowers were harvested and the seed production estimated for each treatment. The vegetative portions of the plants were then weighed and dried. The percent dry matter for each treatment was calculated. The experiment was terminated on September 28, 1963.

Results and Discussion

The heights of corn chamomile plants as influenced by the nitrogen treatments are presented in Table I.

Table I. Average heights of corn chamomile plants at various dates of measurement as influenced by levels of nitrogen.

Date of Measurement	Average Height - Centimeters		
	High N	Medium N	Low N
May 28	9.47	7.46	9.42
June 4	14.18	9.58	10.12
June 8	17.50	11.54	10.37
June 15	22.37	15.33	11.25
June 23	26.50	17.17	12.50
July 14	42.75	20.83	14.67
July 23	47.25	20.92	14.83
August 1	53.00	22.08	14.83
September 28	74.74	36.58	19.97

The lower average height of the medium nitrogen treatment at the initiation of the experiment, on May 28, was caused by the replacement of a dead plant with a smaller one.

The effects of nitrogen on growth are presented graphically in Figure I. The plants growing in high and medium nitrogen levels grew almost equally from May 28 to June 15. The curves in Figure I are misleading because the medium nitrogen plants were shorter at the beginning of the experiment. Had they been equal to the high nitrogen plants, the growth curves would be similar from May 28 to June 15. The sharp increase in the growth curve of the high nitrogen treatment on June 23 coincided with the initiation of flowering. When flower heads form, peduncles elongate rapidly. The medium nitrogen plants leveled off in growth after June 15 until July 13 when one of the replications started to flower causing an increase in growth. Low nitrogen plants had a low growth rate but continued to grow slowly and manifested no nutrient deficiency symptoms.

High nitrogen plants produced an average number of 898 flowers per plant from the time of initiation until the termination of the experiment. Since the average size flower head produced 140 seeds, the average seed production per plant in the high nitrogen treatment was approximately 125,720 seeds. Flowering started in the medium nitrogen plants more than a month after the high nitrogen plants and never started in the low nitrogen plants.

The comparative size of the corn chamomile plants grown under the different nitrogen are summarized in Table II. The high nitrogen plants weighed considerably more than either the low or medium nitrogen plants and they had a lower dry weight indicating greater succulence.

At the termination of the experiment, the plants were still actively growing.

Table II. Average fresh weight, dry weight and dry matter of corn chamomile grown under three levels of nitrogen.

Nitrogen Level	Fresh Weight (gms)	Dry Weight (gms)	Dry Weight Percentage
140 ppm	1534	230	16
42 ppm	650	146	23
14 ppm	212	50	24

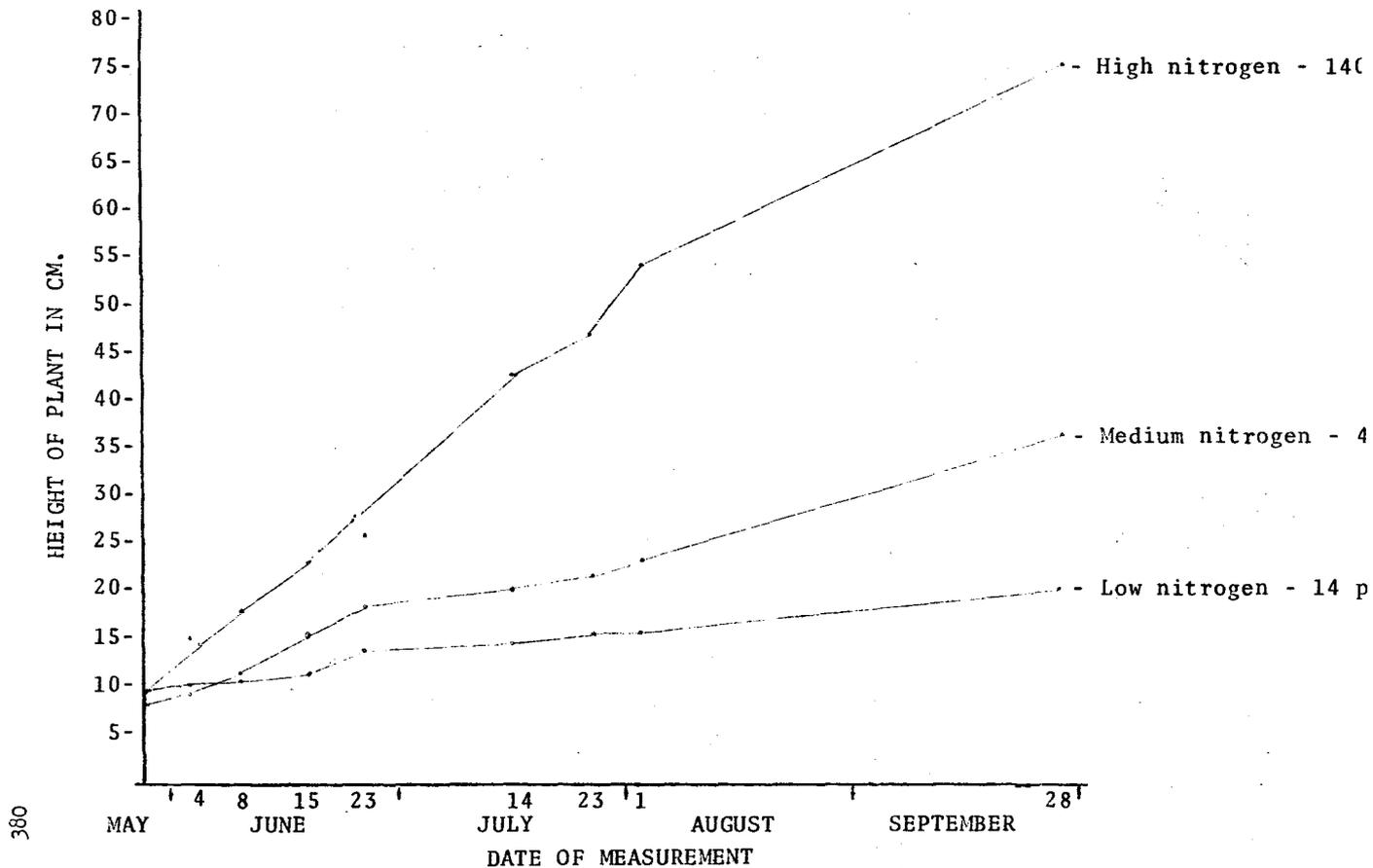


Figure I. The growth response of corn chamomile (Anthemis arvensis) to three levels of nitrogen.

Conclusions

Results from this experiment verify some previous reports that a high level of nitrogen nutrition does not inhibit flowering in certain plant species. With corn chamomile, when nitrogen is lacking, then flowering is delayed.

Corn chamomile has a tremendous seed production capacity when adequate nitrogen is supplied.

That corn chamomile remained active and healthy with a low supply of nitrogen demonstrates the minimal growth requirements of this weed species.

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SUMMARY OF QUACKGRASS CONTROL STUDIES WITH
ATRAZINE IN MASSACHUSETTS¹

Jonas Vengris²

ABSTRACT

In the last five years, over ten field and greenhouse trials were conducted to develop practical methods of controlling quackgrass (Agropyron repens L.) with 2-chloro-4-ethylamino-6-isopropylamino-s-triazine (Atrazine). With the exception of greenhouse experiments, all field tests were conducted on areas planted to field corn. A gravelly sandy loam with good drainage and a uniform stand of quackgrass was used. Seedbed preparation and fertilization practices and also the corn variety used were the same for each trial. Varying rates of herbicide applications, different times and different methods of applications were studied. The value of cultivation in addition to the use of an herbicide was also investigated.

A rate of 2-4 lb/A of actual atrazine provided practical control of quackgrass. The herbicide can be applied in the fall or in the spring on quackgrass foliage, on a prepared seedbed at time of planting or 2-3 weeks after corn has been planted. The best quackgrass control was consistently obtained with fall applications made before the middle of October. The effectiveness decreased following this date of application. It is thought that the differences in effectiveness can be explained by soil and weather moisture conditions. Good soil moisture conditions immediately after the application are of first importance. Greenhouse and field tests both indicate that the incorporation of atrazine into the soil may be advantageous. Placing the chemical closer to the mass of rhizomes where soil moisture conditions are better seems to facilitate absorption of atrazine by the roots. For best results when atrazine is used at planting time, it is suggested that atrazine be applied on a prepared seedbed and disked in 3-4 inches deep. If annual weeds are also serious, it is suggested that 2 lb/A be applied in the fall or early in the spring and 2 lb/A incorporated into the seedbed at planting time. One cultivation when corn is about one foot tall significantly improves quackgrass control. This improvement it seems comes from the cultivating operation itself and not from increasing the effectiveness of the herbicide.

With the higher rates of atrazine (4 lb/A and above), the importance of date of application, incorporation into the soil, or cultivation is reduced.

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1. Contribution of Massachusetts Agricultural Experiment Station, College of Agriculture, University of Massachusetts, Amherst, Massachusetts.
 2. Associate Professor, Agronomy Department, University of Massachusetts, Amherst, Massachusetts.

CONTROL OF VELVETLEAF (*Abutilon theophrasti*)^{1/}
WITH TRIAZINE COMPOUNDS - GREENHOUSE SCREENINGS^{2/}

Armin H. Furrer, Jr. and Stanford N. Fertig^{2/}

Introduction

Velvetleaf (*Abutilon theophrasti*) Medic., an annual, is in the Mallow (Malvaceae) family. It is a problem in corn and other row crops. Seeds are known to maintain viability for over 50 years when buried in soil. The seeds of this species are one of few which will survive the ensiling process (1).

Poor control of velvetleaf has been observed under field conditions following the application of triazine compounds. This may be associated with physiological resistance, timing of application, or depth and time of emergence of the velvetleaf plants.

A greenhouse experiment was initiated in the summer of 1963 to determine the:

- (1) extent of emergence of seedlings from seed planted at various depths in soil,
- (2) relationships between depths of planting and pre-emergence treatments on the effectiveness of control with triazine compounds, and
- (3) treatment stage at which triazine compounds are most effective in controlling this weed.

Materials and Methods

Six seed planting depths were selected: 1/4, 1/2, 1, 1-1/2, 2, and 3 inches. Soil containers consisted of plastic flower pots measuring 4 inches in depth and 4 inches in top diameter. Fertilizer was mechanically incorporated with soil at the rate of 1,000 pounds of 5-20-20 per acre based on 2 million pounds of soil per acre furrow slice. Six velvetleaf seeds, harvested in 1962, were planted in each pot.

Nineteen chemical treatments were used. These are listed in Table 2. All treatments were replicated 4 times for each depth of planting. Pre-emergence treatments were applied 2 days after planting. Post-emergence treatments were applied 10 days after planting when most of the velvetleaf seedlings were 1 to 2 inches tall. The applications were made using a table sprayer having a revolving belt.

^{1/} Work supported in part by funds made available through Station Project Hatch 50.

^{2/} Research Specialist and Professor of Agronomy, respectively, Department of Agronomy, Cornell University, Ithaca, New York.

Observations and stand counts were made 19, 27, and 42 days after planting.

Results and Discussion

Under favorable growing conditions of adequate moisture, friable soil, and warm soil temperature, emergence of velvetleaf seedlings was rapid. Four days after planting, many plants had emerged from seed planted 1/4 to 2 inches deep and one plant from the 3 inch depth. Thereafter, emergence was very rapid. It is estimated that at least 95 percent of total emergence had occurred at the time post-emergence treatments were applied.

Table 1 shows the extent of emergence of seedlings from the various depths. Each figure is the average of 4 replications of the untreated check. The stand count was made 42 days after planting.

Emergence of Velvetleaf Seedlings From Seeds Planted at Various Depths In Soil						
Depths of Planting (inches)	1/4	1/2	1	1-1/2	2	3
Percent Emergence-Average of 4 Replications	79	88	79	79	71	42

The average emergence from all depths of planting was 73 percent. These data and observations show that velvetleaf seedlings characteristically emerge rapidly, are extremely vigorous, and readily emerge from seed located at soil depths of 3 inches or more.

Table 2 is a summary of control (percent kill) of velvetleaf plants by treatment and depths of planting from 1/4 to 2 inches. Each figure under "depths of planting" is based on stand counts made 42 days after planting and is the average of 4 replications.

All pre-emergence treatments, except atrazine, gave essentially no control of velvetleaf. The control with atrazine at 1 pound per acre (treatment 5) was poor. At the 2 pound rate (treatment 6), the control was fair. The data indicates an inverse relationship between depth of planting and control at the 2 pound per acre rate of atrazine applied pre-emergence - the shallower the planting, the better the control. This may partially account for the poor control with pre-emergence applications of atrazine under field conditions.

Table 2

Percent Kill of Velvetleaf Plants
With Triazine Compounds Applied Pre- and Post-Emergence

Treatments*	Rate/A. ai.		Percent Kill at Each Depth of Planting** (in.)					Ave. kill for all depths (percent)
	Pre- Emerg.	Post- Emerg.	1/4	1/2	1	1-1/2	2	
1. Simazine	1.0	---	17	16	0	8	0	8
2. Simazine	2.0	---	0	0	0	0	0	0
3. Prometryne	1.0	---	0	6	16	0	0	4
4. Prometryne	2.0	---	0	0	6	0	8	3
5. Atrazine	1.0	---	37	30	68	15	18	34
6. Atrazine	2.0	---	95	63	58	19	25	52
7. G-36393	1.0	---	0	0	0	0	0	0
8. G-36393	2.0	---	0	0	0	0	6	1
9. G-34690	1.0	---	0	0	0	0	0	0
10. G-34690	2.0	---	0	0	0	0	0	0
11. Atrazine	---	1.0	91	73	70	31	100	73
12. Atrazine	---	2.0	95	81	94	89	96	91
13. Prometryne	---	1.0	96	97	50	95	94	86
14. Prometryne	---	2.0	94	100	86	88	94	93
15. G-36393	---	1.0	90	91	95	89	94	92
16. G-36393	---	2.0	68	85	83	100	95	86
17. G-34690	---	1.0	97	100	100	87	--	96
18. G-34690	---	2.0	82	100	100	92	89	93
19. Check	0.0	0.0	0	0	0	0	0	0

* All chemicals in wettable powder form; applied in 18 gpa.

**Average of 4 replications.

Very good to excellent control was obtained with post-emergence applications of atrazine at 2 pounds per acre and prometryne, G-36393, and G-34690 at 1 and 2 pounds. The 1 pound per acre rate of atrazine was somewhat weak.

Summary

During the summer of 1963, a greenhouse experiment was conducted to determine the effectiveness of triazine compounds for the control of velvetleaf (Abutilon theophrasti).

Seeds were planted in soil at depths of 1/4 to 3 inches and treated pre- and post-emergence with several triazine compounds at rates of 1 and 2 pounds per acre.

The results show that:

- (1) velvetleaf seedlings readily emerge from seed planted in soil at depths of 3 inches or more,
- (2) pre-emergence treatments generally give poor control, and

- (3) post-emergence treatments give excellent control at 2 pounds per acre applied when velvetleaf seedlings are 1 to 2 inches tall.

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Light Effects on Weed Seed Germination¹

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New Hampshire Agricultural Experiment Station

This is a report on seed germination of five different weeds common in the Northeastern United States. They were selected by the NE-42 Technical Committee of the Northeast Region for study of weed life cycles. The weeds are: (a) Crabgrasses (Digitaria spp.), (b) Barnyard grass (Echinochloa crusgalli (L.) Beauv.), (c) Mayweed (Anthemis cotula L.), Corn chamomile (A. arvensis L.), (d) Yellow rocket (Barbarea vulgaris R. Br.), (e) Pennsylvania smartweed (Polygonum pennsylvanicum L.) and Ladysthumb (Polygonum persicaria L.). Samples of seeds for tests of light effects on germination at the New Hampshire Station were secured locally and from other Stations of the region as indicated in Table 1. This is a part of a broad program of research on weed life cycles, designed to provide basic information on how light quality affects different phases of weed growth. In this study only white fluorescent light was used and its effects compared with those of total darkness, to determine the light requirement, if any, for good germination.

Experimental Procedure

A standard method for testing light effects on germination was used as outlined by Steinbauer and Grigsby³. In all germination tests 5 seed lots of 100 seeds per lot were used for each treatment in any single test. Two kinds of moistening agents were used, distilled water and 0.2% KNO₃. The seeds were sown on two layers of filter paper (Fisher #9-795) placed in the bottom of glass petri dishes. Ten mls of the desired moistening agent were added to all dishes. Four sets (5 seed lots each) received distilled water as a moistening agent while four others received 0.2% KNO₃. One set of each four received one of the following light exposures from cool white fluorescent lamps set at 100 ft-c (corrected): 0-hour (darkness), 1-hour, 8-hours, and 168-hours (continuously illuminated). Final germination counts were taken at the end of 7 days. The room temperature was 70° F. for 16 hours and 60°F. for 8 hours daily.

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This study was part of Northeast Regional Project NE-42, Weed Life Cycles as Related to Weed Control in the Northeast; a cooperative study involving Agricultural Experiment Stations in the Northeastern Region and supported in part by regional funds.

²Graduate Research Assistant and Plant Physiologist, respectively.

³Steinbauer, G. P., and B. Grigsby. 1957. Interactions of temperature, light, and moistening agent in the germination of weed seeds. Weeds 5: 175-182.

Results and Discussion

The results of all seed germination tests are given in Table 1. Those results for certain samples of seeds that showed marked differences in response to treatment also are presented graphically in Figures 1 and 2. They will be discussed in the order given in Table 1.

Barnyard grass, Echinochloa crusgalli (L.) Beauv., Delaware, 1961. Increase in length of light exposure caused marked increase in germination, being greatest (67.6%) with 168 hours of continuous light and dilute KNO_3 as moistening agent. There was a relatively small advantage for 0.2% KNO_3 as moistening agent over germination with distilled H_2O except in the 1 hour light exposure. See Figure 2b.

Barnyard grass, E. crusgalli (L.) Beauv., Mass., 1962. Germination was very low for these seeds and there was little difference in response to any of the treatments. To aid in breaking dormancy these seeds were moistened and stored at 40°F . for one week prior to exposure to the standard light treatments. They also were kept for an additional time in darkness to the extent of one month, to allow further germination. Counts of germination were made once a week. Other lots of seed were kept for this length of time in continuous light. Neither of these extra treatments induced much response, the highest observed being 3.4% germination.

Mayweed (dog fennel), Anthemis cotula L. Vermont, 1961. Light exposure proved to be very beneficial in the germination of these seeds, with a steady increase from 6.6% for darkness (0.2% KNO_3) up to 66.6% for the longest exposure of 168 hours of light. The treatment with dilute KNO_3 as wetting agent gave consistently higher (about double) germination than with distilled water. The results are shown graphically in Fig. 2c.

Corn chamomile (dog fennel), A. arvensis L., N. J., 1962 (32 mesh, 26 mesh, and 20 mesh). These three lots of seeds will be considered together, since they differ chiefly in the size of seeds. It is evident that the percentage of germination is much higher in the smaller seeds; the larger ones (20 mesh) showing almost zero germination. There was considerable benefit to germination from increasing light exposure, especially in the smallest seeds (32 mesh) and with dilute KNO_3 as wetting agent, as shown in Fig. 2d. The combination of light exposure with distilled water as wetting agent did not show this increase to any extent.

Yellow rocket, Barbarea vulgaris R. Br., N. H., W. Va., and N. Y., 1962. Three different states supplied samples of this seed, as noted above. The results for W. Va. seed are graphed in Fig. 1a and those for N. Y. seed in Fig. 1b. Again as with some other seed samples, increase of length of light exposure caused marked increase of germination with 0.2% KNO_3 as wetting agent. This light effect was not nearly so great with distilled water; in fact, the longest exposure of 168 hours of continuous light here caused a decrease in germination compared to that with 8 hours of light. For the seed from W. Va. and N. Y. the effect of darkness was not nearly so inhibitory to germination as it was with the N. H. seed.

Pennsylvania smartweed, Polygonum pennsylvanicum L., R. I., 1961. Increase in length of light exposure caused a steady increase in germination of these seeds, but there was no distinct advantage for treatment with KNO_3 solution as compared to distilled water. Germination was enhanced by preliminary storage at 40°F . for one week in a moist condition. Germination results are graphed in Fig. 1c.

Ladysthumb (smartweed), Polygonum persicaria L., R. I., 1961. Benefit from light exposure was much less pronounced than with other species. Eight hours of light exposure, with distilled water as wetting agent, gave highest germination of all treatments, 64.0%. Except with continuous light for 168 hours, distilled water was better than KNO_3 solution as wetting agent. Graphs for these seeds are in Fig. 1d.

Crabgrass, Digitaria spp. (Species were D. ischaemum (Schreb.) Muhl. and D. sanguinalis (L.) Scop). Several samples of crabgrass seeds were tested, four from Conn., one from Md., and one from N. H. Only one sample, the small seed from Conn., 1961 (Fig. 2a), showed much effect either from differences in light treatments or from different wetting agents. With this sample of seed there was a general increase in germination along with increasing length of light exposure. There was also some advantage for dilute KNO_3 solution over distilled water, except for the longest light exposure of 168 hours.

All of the other crabgrass seed samples (with one exception) responded with uniformly high germination from all treatments, indicating no particular sensitivity to light or to difference in wetting agent. The one exception, the large seed from Conn., 1961, gave zero germination throughout. Like the results with corn chamomile, we think this indicates a tendency for larger seeds to be less viable than smaller ones.

Summary

Seed samples of five different types of weeds common in the northeastern United States were tested for germination response under standard conditions with darkness and different lengths of light exposure, as well as two different wetting agents, distilled water and dilute KNO_3 solution. Several general conclusions may be drawn from the results:

1. Most of the samples tested showed a sensitivity to light, germinating at higher percentages with longer exposures to light.
2. Dilute KNO_3 solution usually gave better germination than distilled water as wetting agent.
3. Small seeds appear to germinate at higher percentages than larger seeds of the same or a similar seed lot.
4. Dormancy of seeds often may be broken by cold or acid treatment.
5. Some lots of seed require a much longer time than one week to germinate.

Fig. 1 Mean Percent Germination of Weed Seeds.

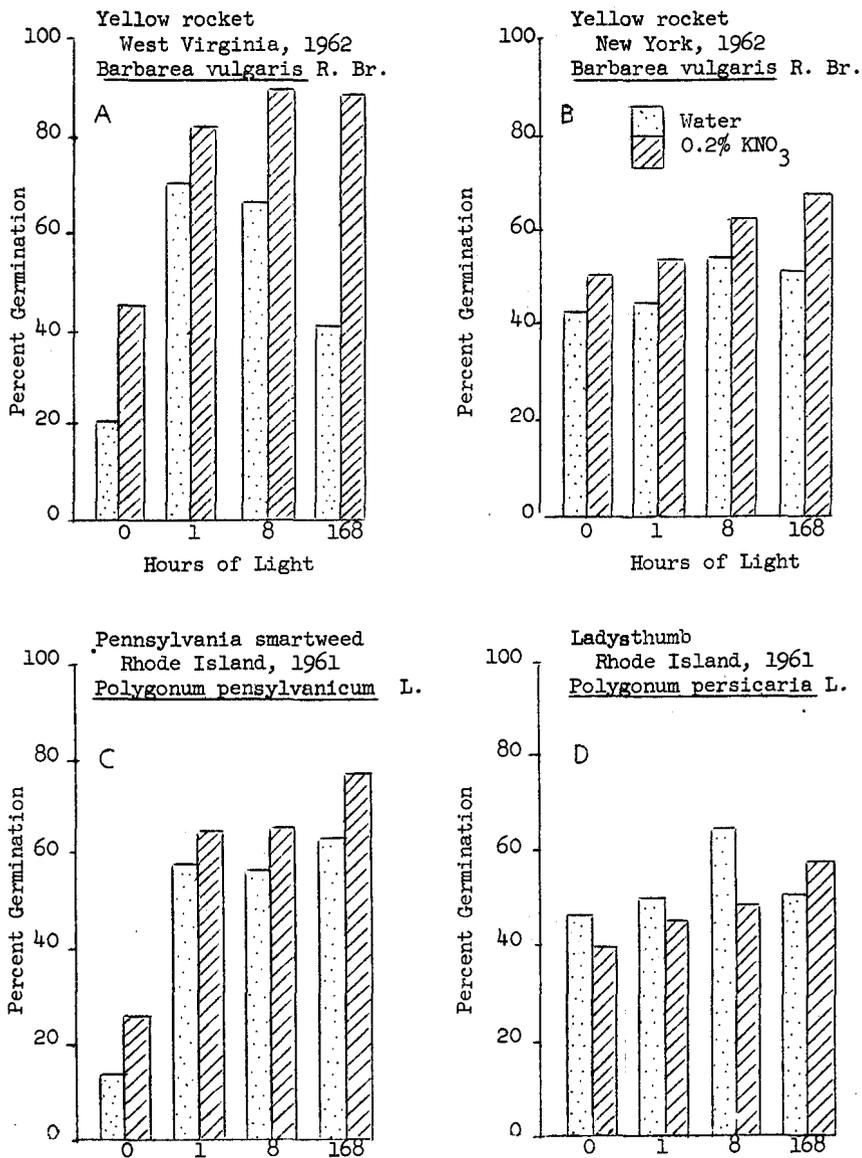
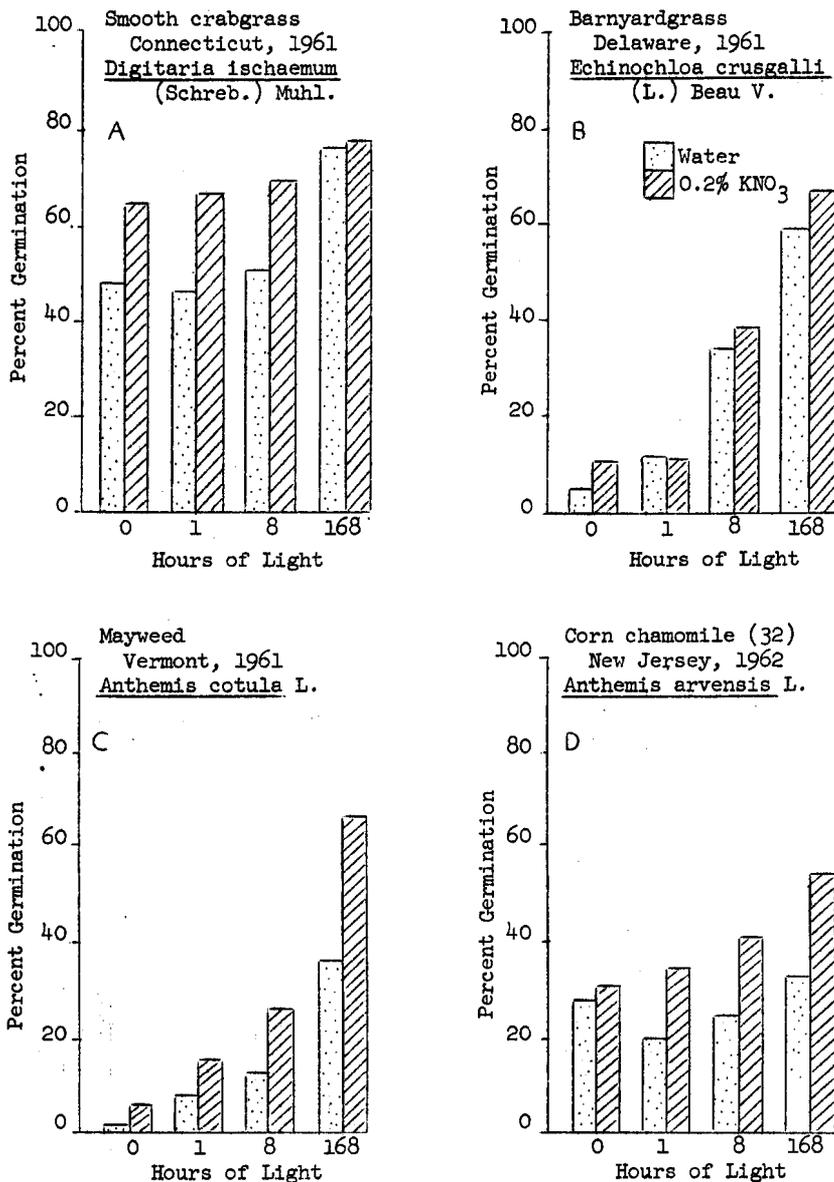


Fig. 2 Mean Percent Germination of Weed Seeds.



VEGETATION AND BRUSH CONTROL WITH HEXAFLUOROACETONE TRIHYDRATE

Roger L. Pierpont and William J. Cunningham (1)

Highway, railroad and industrial vegetation and brush control problems continue to increase each year as new construction adds thousands of miles and acres of vegetation to maintain and control. Traditional cultural practices are no longer economically practical, and effective plant growth control is obtained by using herbicides.

Extensive research conducted in an effort to find more effective chemical tools for use as herbicides shows that hexafluoroacetone trihydrate (GC-7887) effectively controls vegetation and brush when standard application practices are followed.

The purpose of this paper is to describe hexafluoroacetone trihydrate to members of this conference, and discuss results obtained with it on broadleaf weeds, grasses and woody plants.

Chemical and Physical Properties

The trihydrate ($\text{CF}_3 - \underset{\text{O}}{\text{C}} - \text{CF}_3 \cdot 3\text{H}_2\text{O}$) is a colorless liquid with a boiling point of 105°C (approx.), freezing point of -11°C (approx.), and specific gravity of 1.59. It is soluble in water, and insoluble in most organic solvents.

Formulation and Activity

Hexafluoroacetone trihydrate is a water-soluble liquid. It acts primarily as a systemic herbicide but has some contact action. Usually herbicidal effects are indicated by necrosis, plant deformation and retardation with little chlorosis evident.

Field Tests

Annual and Perennial Weeds

In field tests 1 to 2 gallons of hexafluoroacetone trihydrate per acre in sufficient water to wet plant foliage thoroughly, gives good control of mixed weed populations. Established plants are killed and reinfestation from seeds prevented for a period of time. Rainfall soon after application may reduce the effectiveness of the treatment. The residual effectiveness depends upon how fast the herbicide is removed by moisture from the seed germination region of the soil.

(1) General Chemical Division, Allied Chemical Corporation,
Morristown, New Jersey

Residual weed control can be maintained by combining hexafluoroacetone trihydrate with a more persistent soil sterilant, as it enhances the activity of other herbicides, e.g., diuron and isocil. When tested as pre- and post-emergence and soil incorporation treatments for the control of weeds in crops, and pre-emergence for the control of crabgrass in established turf, excessive crop and turf injury occurred. Typical test results are presented in Table 1.

Table 1 Weed¹ Control Tests - Hexafluoroacetone Trihydrate (GC-7887) Alone and in Combination with Isocil and Diuron

Treatment	Rate/A*	% Top Kill				
		6/28	7/25	8/7	8/21	9/24
GC-7887	2 qt.	5	75	75	65	40
GC-7887	4 qt.	5	90	95	95	80
GC-7887	8 qt.	10	98	99	99	95
Isocil	8 lb.	0	35	75	75	75
Isocil	16 lb.	5	90	95	95	95
GC-7887	2 qt.	5	80	90	90	95
+	+					
Isocil	5 lb.					
GC-7887	4 qt.	15	95	98	98	98
+	+					
Isocil	5 lb.					
GC-7887	2 qt.	5	35	75	80	90
+	+					
Diuron	10 lb.					

* Applied June 26

1 -Weeds include: broadleaf plantain (Plantago major), narrow leaf plantain (Plantago lanceolata), dandelion (Taraxacum officinale), wild carrot (Daucus carota), goldenrod (Solidago spp.), common ragweed (Ambrosia artemisiifolia), grasses (Bromus spp., and Setaria spp.)

Brush

Hexafluoroacetone trihydrate has been very effective in foliage applications for brush control. At higher concentrations top-kill and defoliation is rapid. Complete coverage, and basal, dormant and early spring applications also have proven to be effective. Soil injection of hexafluoroacetone trihydrate into the root zone defoliated oak, maple, dogwood and sassafras. Tables 2 and 3 present typical field test results.

Table 2 Brush Control Test - Hexafluoroacetone Trihydrate
(GC-7887) Foliage Application¹ 2 Gal./100 Gal. Water

<u>Species</u>	<u>Percent Top Kill</u>			<u>Percent Defoliation</u>		<u>Percent Second Year Regrowth</u>		
	<u>8/6</u>	<u>8/14</u>	<u>9/10</u>	<u>8/14</u>	<u>9/10</u>	<u>5/24</u>	<u>7/2</u>	<u>8/28</u>
Dogwood	100	100	100	95	100	0	5	50*
Birch	100	100	100	100	100	0	0	0
Maple	95	100	100	80	100	5	5	5
Poplar	95	99	100	99	100	0	0	0
Sumac	95	100	100	100	100	0	0	0
Cat-tail	90	90	100	---	---	Normal regrowth		

* From roots

1 - Applied August 1

Table 3 Brush Control Test - Hexafluoroacetone Trihydrate
(GC-7887) Foliage Application¹

<u>Species</u>	<u>Rate/100 Gal. Water</u>	<u>% Top Kill</u>			<u>% Defoliation</u>		
		<u>8/23</u>	<u>9/10</u>	<u>10/11</u>	<u>8/23</u>	<u>9/10</u>	<u>10/11</u>
Birch	2 qt.	---	70	100	---	40	100
Dogwood	4 qt.	70	100	100	35	100	100
	2 qt.	40	100	100	---	100	100
	1 qt.	25	25	85	---	15	85
Elm	4 qt.	60	100	100	50	100	100
	1 qt.	20	95	100	---	80	100
Mock Orange	2 qt.	---	70	100	---	40	100
	1 qt.	20	100	85	---	30	85
Poplar	4 qt.	95	100	100	75	100	100
	2 qt.	30	---	95	---	---	95
	1 qt.	10	10	95	---	10	95
Sumac	4 qt.	85	100	100	---	100	100
	2 qt.	35	100	100	---	100	100
	1 qt.	30	70	100	---	60	100

1 - Applied August 15

Summary

Hexafluoroacetone trihydrate is an effective, non-selective, systemic weed and brush killer. Rates of 1 to 2 gallons per acre alone, or at reduced rates with other herbicides are suggested for the control of annual and perennial weeds.

Very effective brush control was obtained with complete coverage foliage applications of 1 to 2 gallons of hexafluoroacetone trihydrate per 100 gallons of water. Dormant and basal treatments were also effective.

The non-selective, systemic effects of hexafluoroacetone

Back-Pack Mist Blowers as a Tool for Chemical
Brush Control on Power Company Right-of-Way

Allyn W. Coombs and Laurey C. Kenerson*

Several factors must be considered for successful brush control on transmission line right-of-way. Cost is the most important factor in the selection of a control method. Chemical application may prove expensive because of inaccessability, adverse terrain, and the high volume sprays usually employed. Proper choice of equipment and chemicals can serve to reduce cost while giving satisfactory control. Ground application of spray in many instances may be the most effective and economical means of brush control on power lines. An efficient, highly mobile unit is required. The back-mounted mist blower is light, compact and highly portable making it possible to spray wherever a man can walk. Modern herbicides can be applied through these machines in highly concentrated form to efficiently cover large areas with a low volume spray at modest cost. These and other associated features make this method superior to other ground application methods which have been developed in the past. This method was used by a private company formed by the authors during the past summer to spray 525 acres of right-of-way in Western Massachusetts for the New England Power Company.

The right-of-way, 270 feet wide and containing three transmission lines, extended from the Connecticut River into the Berkshire Mountains. It crossed some very rough terrain with elevations changing abruptly from 200 to 1300 feet. The species on the right-of-way were predominately hardwoods with only a scattering of conifers. The most common species were birch, maple, cherry, oak and poplar.

A mist blower of Dutch¹ manufacture was selected. This machine has a four horse power blower which generates 780 cubic feet of air per minute with a nozzle velocity of 180 miles-per-hour. The high air velocity provides deep penetration and a 40 foot vertical reach where necessary.

A Chevrolet half-ton four wheel drive pick-up was used as a supply vehicle and to transport workers. The spray mixture was carried in two fifty gallon drums permanently mounted in the truck.

After consulting the literature to find a chemical formulation with the desired characteristics an invert emulsion of 245-T and 24-D was chosen. This herbicide has the advantage of good brush control characteristics, reduced drift hazard, and non-caustic properties. Invert emulsions have been applied successfully to power lines by helicopters.

An invert emulsion is a thick, white, water in oil, emulsion as opposed to the conventional oil in water emulsion. The thickness of the mixture re-

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¹Kiekens KWH model 77 TT.

duces drift hazard and increases the deposit of herbicide on the foliage. The emulsion has a consistency equal to number 30 motor oil and flows well through the mist blower.

The invert emulsion formulation¹ selected to meet the requirements contains two pounds of 245-T and two pounds of 24-D per gallon. It is prepared by mixing one part of the chemical to one part fuel oil and adding four parts of water with mild agitation. The mixture is very stable and easy to handle.

Work began in mid-June and was completed in late August. The 525 acres in the contract were completed in fifty working days. The spray was applied with a three man crew using two mist blowers. The two men walked back and forth across the right-of-way fifteen feet apart spraying ten feet on either side of their travel line and overlapping in the middle. They covered a thirty foot strip with each double pass. The men oriented themselves by guiding on toilet paper placed to mark the previous strip so that good coverage was obtained.

A three man crew was necessary. While two men were spraying, the third moved the supply vehicle to the new loading point or was resting. The third man alternated with the other two on the mist blowers giving each man a thirty minute rest period after an hour of spraying. Loaded, the machine weighs sixty pounds making a rest essential for efficient operation.

A machine load contains three gallons of spray. Under average conditions this covered 0.5 acres, which means that four pounds of acid equivalent, two pounds 245-T and two pounds 24-D, are applied per acre. The amount of spray applied varies with the height and density of the brush. Applications varied from as little as two pounds per acre to as much as sixteen pounds per acre depending on brush conditions. This variation is under the control of the operator. He can vary the amount applied to any given area by adjusting the flow through the machine or by changing his rate of travel. While this is an efficient method of broadcast application, it can be used rather specifically depending on brush conditions. It is in this respect superior to aerial application.

Many problems are encountered in this kind of operation and a few deserve mention here. Although a man can walk almost anywhere, on steep side hills where the brush was extremely dense and tangled with grapevines, spraying became difficult and slow. These areas, fortunately, made up only a small percentage of the right-of-way. On extremely hot days the men soon became exhausted. Therefore, during hot weather work was started at daybreak and stopped when the heat became unbearable. Care had to be exercised while spraying during hot weather to avoid damage from volatility. This problem only occurs in areas where there are agricultural crops or ornamental plants near the right-of-way. Drift was not a problem with the spray mixture used. The large droplets settle quickly and are not carried far by the wind. However, spraying ceased when the wind was greater than fifteen miles per hour

¹Verton CE. The Dow Chemical Company.

because it was difficult to get good spray coverage. Much spraying time was lost because of high wind velocities.

The job was contracted on a line acre basis with a 60% root kill guaranteed. Results will be determined in June 1964 by plots measured along the entire length of the right-of-way. The preliminary results showed a slow but uniform brownout, indicating a good kill based on past experience, but it is too early to make a definite appraisal of results. In summary, the high mobility of the back-pack mist blower, the small amount of spray required to cover large areas, combined with the opportunity to vary the volume applied to suit the kind of brush, makes this type of operation very versatile for use on power lines and its use should be increased in the future.

PARTICULATE SPRAYS FOR REDUCING DRIFT
FROM HERBICIDE APPLICATIONS

By

K. G. Seymour and B. C. Byrd¹

Spray drift, as a problem of major importance in the pesticide field, needs little introduction to those who work in this field. The factors affecting the formation and drift of spray droplets have been adequately discussed in the literature. Taken in summary, the results have pointed to one basic problem: that of the production of spray droplets which are large enough to resist the drift caused by air movement, but small enough, in aggregate, to give the type of coverage required for adequate pesticidal efficacy.

This paper describes a new concept of spraying which appears to have particular value for reducing spray drift.

If a single particle of a water-swellable polymer is placed in an aqueous solution, the particle will imbibe liquid and swell to some limited size. The final swollen size of the particle will be determined by the type of polymer used. As more particles of swellable polymer are added, more and more of the liquid will be imbibed until a point is reached where essentially all of the liquid has been taken up and immobilized by the swollen polymer particles. The original solution is then present in an array of separate, distinct particles whose size and shape are predetermined by the nature of the original dry polymer granules. This array of individual swollen particles may properly be regarded as a "granular liquid". It can be poured, pumped and sprayed. The individual swollen polymer particles will largely separate when sprayed. Such a spray may properly be termed a "particulate spray". Norbak* particulating agent for sprays is a water-swellable polymer which produces particulate sprays essentially in the manner described above.

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* Trademark of The Dow Chemical Company.

Viscosity and Flow Characteristics

Consistency of solutions particulated with Norbak varies with the amount added to a given volume of solution. We have found that the Krebs number (ASTM Method D-562) paint consistency test gives convenient values for correlating with degree of drift reduction and overall handling properties. Figure 1 shows the consistency obtained with varying additions of Norbak to a solution containing the potassium salt of Tordon* herbicide (4-amino 3, 5, 6-trichloropicolinic acid). Consistency corresponding to a Krebs number of 110 or less has been found to have good handling properties.

Some conventional viscosity measurements on solutions thickened with Norbak give inconsistent results. Smooth cylinders appear to spin in the material without appreciable flow of the bulk material, and flow in tubes tends to be by plug flow. These types of viscometers thus give readings relating to wall friction, but their sensitivity to shear rate makes the results difficult to use for routine consistency evaluation. Figure 2 shows viscosity data obtained from a solution of Tordon particulated with Norbak to a point approximating optimum handling properties and drift reduction. The apparent Brookfield viscosity is quite high at low shear rates, and decreases markedly as the shear rate increases (Figure 2). Brookfield "T" spindles used with a helipath are designed for rheological studies of viscous, non-Newtonian fluids whose prior shear history affects the readings. This method showed a somewhat greater apparent viscosity than did the smooth spindle at a very low shear rate, but at five to 10 revolutions per minute the values agreed quite well (Figure 2).

Wind Tunnel Experiments

The degree of reduction in spray drift from solutions particulated with Norbak was measured in a small wind tunnel. The wind tunnel was designed to give streamline air movement. The spray nozzle was mounted about three feet above the tunnel proper, allowing the smaller droplets to reach terminal fall velocity before entering the wind stream. The center section of the spray fan was isolated by a slit arrangement similar to that used by Courshee¹. The slit was positioned so that all of the spray entering the wind tunnel would either land on the floor or be carried out the end of the tunnel, depending on the droplet size and the wind velocity chosen. One-inch wide plastic strips were placed across the floor at intervals downwind from the nozzle.

* Trademark of The Dow Chemical Company.

¹ Courshee, R. J. Investigations on Spray Drift, Part I: The Small Drop Component of Sprays. J. Ag. Engr. Res. 4:144-152, 1959.

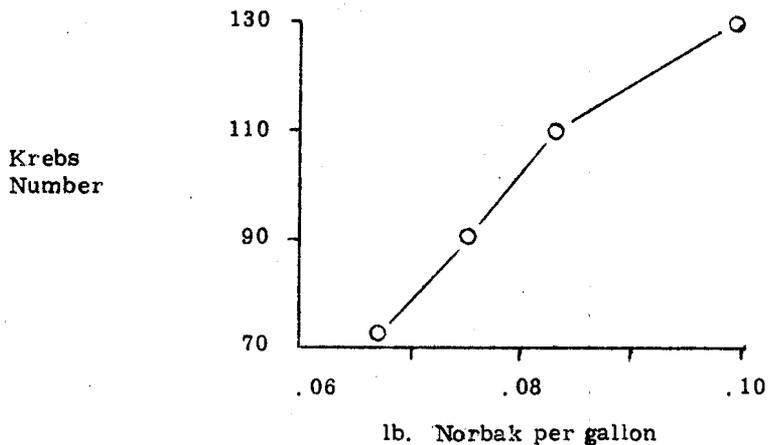


Figure 1. Consistency of a water solution of the potassium salt of Tordon (2 lbs. per 15 gal.) thickened with Norbak.

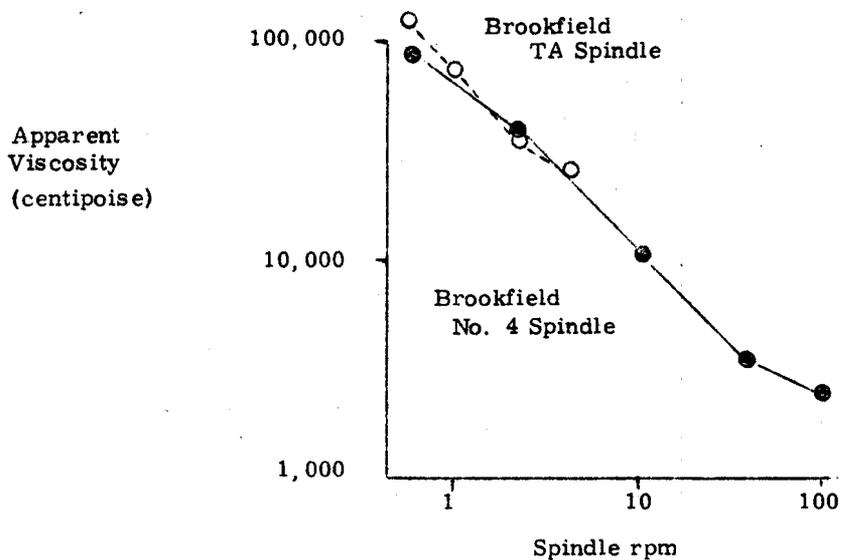


Figure 2. Apparent viscosity of a water solution of the potassium salt of Tordon (2 lbs. per 15 gal.) thickened with Norbak.

All particulate sprays tested in the wind tunnel were first brought to the desired Krebs number, then subjected to 25 passes through a gear pump and a spring-loaded bypass valve to simulate the recycle shearing acting normal to field spraying techniques.

The spray, containing a standard fluorescein concentration, was collected on the plastic strips, extracted, and assayed using a sensitive fluorometer. These data, taken with the fluorescein concentration in the spray and measurement of the amount of spray which entered the wind tunnel, allowed calculation of the fraction of the spray collected on each plastic strip.

The data obtained allowed direct comparison of drift from various spray solutions. The 100 fpm wind velocity and two-foot droplet fall distance employed allowed assay of only the small droplet component of the droplet size distribution curve, effectively excluding droplets larger than 150 microns from the measurement. The results (Figure 3) showed that the particulate sprays produced relatively little drift as compared to conventional sprays. An invert emulsion (Brookfield viscosity 8,300 cps) also showed some reduction in drift. However, invert sprays apparently reduce spray drift by 50 to 95 per cent of aqueous sprays², while the wind tunnel drift data indicated that the particulate sprays reduced spray drift by 98 to 99.5 per cent.

The amount of drift from particulate sprays was found to decrease as the Krebs number increased (Figure 3). In all cases, however, the proportion of drift collected was greatly reduced as compared to conventional aqueous sprays. It thus appears that particulate sprays not only offer a very effective means for reducing drift, but selecting the proper consistency may offer a choice of the degree of drift reduction according to the type of spray operation and the drift hazard concerned.

Concentrations of Norbak Required

The amount of Norbak particulating agent required to adequately thicken herbicide solutions was found to be dependent on the herbicide concentration (Figure 4). Rates of Norbak ranging between 0.5 and 1.5 pounds per acre are required to effectively reduce drift from herbicide applications of 5 to 15 gallons per acre. The amount of Norbak required per acre is dependent on the spray volume. In the presence of the herbicide, water hardness was found to have only a modest effect on swelling capacity (Figure 5).

² Van Valkenburg, J. W. The Physical Properties of Invert Emulsions. Northeastern Weed Control Conference Proceedings 17:365-372, 1963.

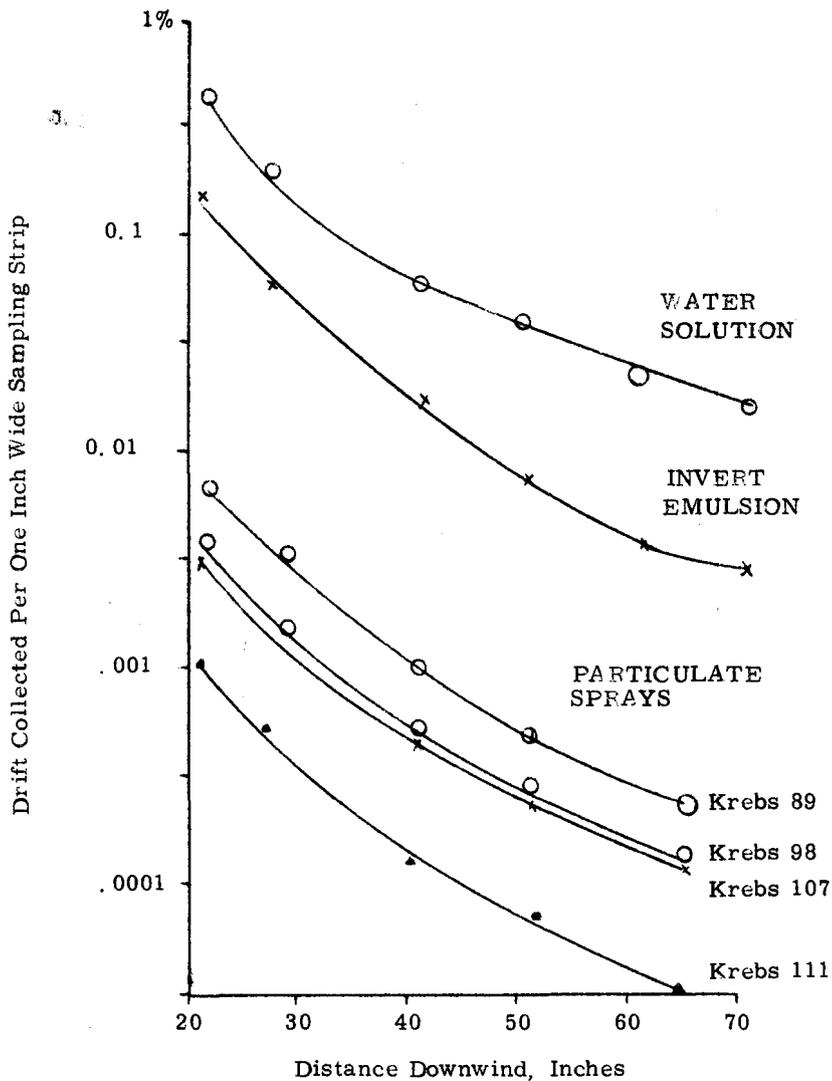


Figure 3 Relative drift from water, invert emulsion and particulate sprays, expressed as per cent of total amount entering the wind tunnel.

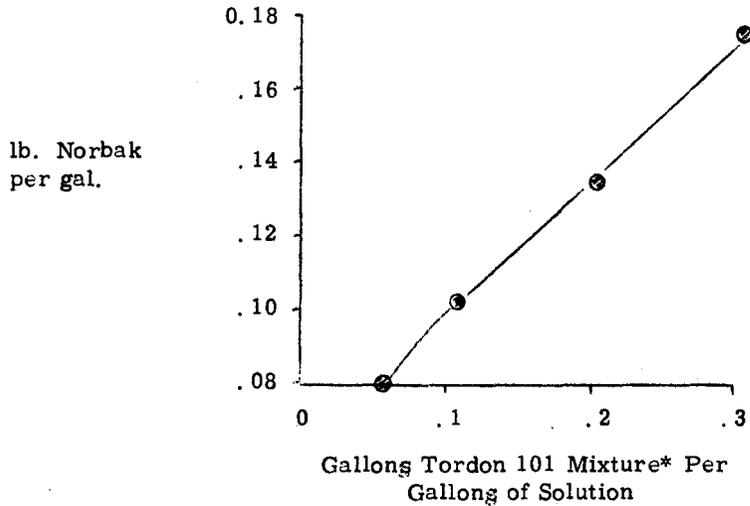


Figure 4. Amount of Norbak required for various concentrations of herbicide sprays.

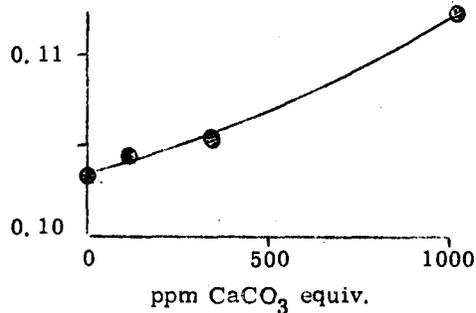


Figure 5. Water hardness effect on thickening capacity of Norbak in a spray solution containing two gallons of Tordon 101 Mixture in eight gallons of water.

* Tordon 101 Mixture contains 2 lbs. /gal. of 2, 4-D and .6 lb. /gal. of Feenamino 3, 5, 6-trichloropicolinic acid.

Spray Characteristics

Relative ease of spraying is one of the critical factors affecting the suitability of viscous solutions for herbicide sprays. Most viscous solutions seriously impair development of the fan spray pattern at viscosities high enough to materially reduce the number of small droplets produced in the spray. Particulate sprays were found to reduce the fan angle from flat atomizing (Teejet) nozzles, as compared to a water spray. The fan angle developed was affected by consistency (Table 1), but nozzle output at a given pressure was relatively unaffected.

Several different spray nozzle types and sizes were tested for use with particulate sprays. It appeared that any nozzle having a simple internal geometry would be operable. Nozzle output was about the same as for water if the orifice was larger than 0.07 inch diameter. Nozzles with an equivalent orifice diameter of .04 to .05 inches reduced the nozzle output about 20 per cent as compared with water sprays.

Herbicidal Efficacy

Herbicidal efficacy in particulate sprays was determined by comparing thickened and conventional sprays of 2,4-D and Tordon at lethal and sub-lethal concentrations of herbicide. Greenhouse experiments showed that particulate sprays did not decrease the herbicidal properties of the potassium salt of Tordon herbicide (Table 2)¹. Similar experiments have shown no decrease in herbicidal efficacy from aqueous sprays of 2,4-D particulated with Norbak.

The "granular" nature of the thickened solutions produced by Norbak allows very thick material to be handled in equipment currently available. However, not all conventional equipment is operable. Positive displacement pumps have been found essential for efficient routine handling of particulate sprays; gear and piston pumps appear to be particularly useful. Centrifugal transfer pumps have been used successfully if the size is appreciably larger than required for water.

Field experience has shown that strainers, screens and other obstructions should be removed from the system. Screens of 50 mesh or larger have been used satisfactorily when small sized nozzle orifices are required.

¹

Experiments conducted by Mr. E. F. Cozart, Research Chemist,
Bioproducts Research Laboratory, The Dow Chemical Company,
Lake Jackson, Texas.

Table 1. Sprayability of solutions thickened with Norbak.

<u>Krebs No.</u>	<u>Fan Angle*</u>	<u>Nozzle Output*</u>
98	52°	0.277 gpm
107	45°	.277
113	40°	.271

* Sprayed with a Teejet 6503 nozzle at 50 psi.

Table 2. Herbicidal efficacy of particulate and conventional solution sprays of the potassium salt of Tordon herbicide applied to bean plants (var. Improved Tendergreen) at 22 gal. spray per acre.

<u>Application Rate,</u> <u>lb. /A.</u>	<u>Per Cent Control*</u>	
	<u>Particulate</u> <u>Spray</u>	<u>Conventional</u> <u>Solution Spray</u>
0.025	50	52
0.125	100	100

* Rated one month after treatment, average of 30 plants.

Tanks with bottom outlets and with gravity feed to the pump have been the most useful. Larger hoses than used for water sprays and booms with at least 3/4 inch ID have performed best in field experiments.

Uniform mixing of Norbak particulating agent in the spray is necessary for satisfactory performance. It is important to obtain complete wetting of Norbak before appreciable swelling occurs. In some cases it is possible to stir the polymer into the herbicide concentrate and slowly pour this mixture into the water as it is being agitated. Eductors have been designed that can be attached to a pumpline to provide adequate dispersion of Norbak in the herbicide solution. Excellent agitation in the tank is necessary during the addition of Norbak regardless of the method employed. Mechanical agitation appears to be the most reliable method and many large spray or nurse tanks in current use are so equipped. Swelling of the Norbak particles is rapid, and only 10 to 20 minutes need be allowed for adequate thickening. Following uniform mixing and adequate swelling the thickened spray solution can stand for extended periods without agitation before spraying.

Conventional boom or cluster nozzles have been successfully used for ground applications at 35 to 50 pounds pressure. Some rearrangement in nozzle clusters may be needed for complete swath coverage because particulate sprays have a different trajectory than do water sprays. Conventional booms and nozzles have proved adequate for helicopter and fixed-wing aerial applications of thickened sprays. Gear or vane pumps have performed satisfactorily for aerial applications, although electrically driven vane pumps should have a rated output of 30 to 50 per cent above the required rating for a comparable conventional application. Oversize lines from the tank to the pump may be advantageous for aerial applications, depending on the pump and power source used.

Field Applications

Sprays containing Norbak particulating agent have been field tested with commercial tank trucks equipped with off-center nozzle tips, tractor-mounted spray equipment with nozzle clusters, truck and tractor-mounted booms, high pressure hand guns, helicopters and fixed wing aircraft. Tordon herbicide formulations were used with Norbak in this equipment. Effective drift control was obtained and herbicidal efficacy was comparable to similar spray applications applied in the conventional manner.

Summary

The concept of particulate sprays was shown to be an effective method for reducing spray drift. Although these sprays are composed of particles rather than liquid droplets, no loss in herbicidal efficacy was observed. Extensive testing showed that the thickened solutions employed can be handled with currently available equipment. Particulate sprays have been useful in allowing safer use of some herbicides near susceptible crops and have permitted aerial sprays to be more accurately placed with only minor loss to drift.

COMPARATIVE STUDIES OF COMMERCIAL
SOIL STERILANTS IN EASTERN VIRGINIA
H. M. LeBaron

There is a relatively large number of herbicides commercially available for soil sterilization and general weed control problems, and this number is increasing. Considerable research has been conducted on each of these materials to determine its effectiveness, susceptible and tolerant species, optimum rate and timing of application, rate of leaching or loss from the soil, and to elucidate other pertinent problems under specific conditions. Seldom, however, are a number of the more promising soil sterilants included in the same study to evaluate these characteristics on a comparative basis.

There are many problems and situations existing throughout eastern Virginia where various degrees of soil sterilization and general weed control are needed. Besides the usual soil sterilization problems connected with industrial sites, driveways, fences, railroads, and highways, the many military bases, particularly the U. S. Naval Installations, and the Norfolk Redevelopment and Housing Authority have extensive and recurring problems ranging from temporary soil sterilization or defoliation to permanent and complete removal of all vegetation. They also range from situations where herbicide cost and economics are of major importance to where desired results are all important and cost is of relatively no consequence.

The most desirable and economical recommendation based on previous research is by no means obvious in many cases. Most commercial recommendations have been worked out under somewhat different soils, climate, and weed population than those prevailing in the Tidewater area of Virginia. This area is characterized by light soils in the fine sandy loam or loamy fine sand classifications, with an annual precipitation of 40 to 50 inches which is, on the average, fairly evenly distributed throughout the year. Problem weeds on noncultivated land, where soil sterilization is generally needed, include, in addition to most of the common annual grasses and broadleaf weeds, a wide distribution of Johnsongrass, Bermudagrass, nutgrass, honeysuckle, trumpet vine (Campsis radicans), Virginia creeper, poison ivy, pokeweed, fennel, and several species of goldenrod, dock, and spurge.

In an effort to develop sounder recommendations for the wide variety of general vegetation control problems in this area, a comparative evaluation was conducted during 1963 on most of the major commercial soil sterilants. This work was an extension of preliminary tests carried out in 1961 and 1962. Because of the characteristic soil and weed problems readily available, most of the work was done on the U. S. Naval Radio Station at Driver, Nansemond County, Virginia.

Early Spring Experiment

The first treatments were applied in early spring on March 20 and 21, 1963. At this time some early weed growth was beginning. All vegetation from the previous year had been mowed or had died back, leaving an open sod except for the new vegetation which was mostly 1 to 2 inches tall, except wild onion which was 6 to 10 inches tall. Materials and rates included in

this test are presented in Table 1 with visual ratings on weed control effectiveness as observed soon after application, on April 4, and about five months after application, on August 14. The weed population which was generally present, when not controlled by treatments, included trumpet vine, buckhorn plantain, dock, goldenrod, annual grasses, Bermudagrass, Johnsongrass, nutgrass, and wild onion. The ratings in Table 1 do not include effects on wild onion. The only herbicide which caused early kill of wild onion was Baron, with spray formulations of Urox, Hyvar, and Hyvar X producing early tip burn and eventual death.

The herbicides listed in order of most rapid and complete effectiveness in this experiment would be Baron, Atrazine, Hyvar or Hyvar X, Urox (LOC), Monuron, and Chlorea. All other materials were relatively slow acting or ineffective. All granular herbicides, with the exception of Atrazine and Chlorea, demonstrated very slow activity. This was largely due to an exceptionally dry spring.

The first rainfall after application occurred on April 7, with a total of 1.23 inches recorded for April, 1.38 inches for May, 9.02 inches for June, and 2.64 inches for July.

By fall, the herbicides listed in order of longest residual action and effectiveness were Hyvar or Hyvar X (WP or G at 10 or 20 lbs/A), Chlorea (G at 650 or 1,300 lbs/A), Monuron (40 lbs/A), Atrazine (WP or G at 40 lbs/A), Ureabor (G at 870 lbs/A), Urox (LOC or G at 40 or 80 lbs/A), Dybar (G at 80 lbs/A), and Diuron (WP at 40 lbs/A). All other herbicides or rates gave poor or unsatisfactory control of some species at the end of the season. There were no apparent differences between Hyvar and Hyvar X. Even 10 lbs/A of either material gave complete season control except for a few severely stunted trumpet vine and grass shoots. Simazine gave poor control of most vegetation throughout the season, even at 40 lbs/A. This superiority of Atrazine compared to Simazine as a soil sterilant is consistent with results obtained in eastern Virginia during the previous two years. Even Atrazine must usually be applied at about 40 lbs/A in order to maintain full season control of grasses. Dybar and Ureabor also gave consistently poor control except at the very high rates of 80 lbs/A and 870 lbs/A, respectively. Baron gave good control for about three months, but did not hold up for the entire season.

Additional observations will be made during 1964 to determine comparative residual effectiveness during the second year, and how soon repeat applications may be necessary in the case of the more promising materials.

Summer Experiment

Some of these same herbicides and other materials were included in a later experiment to evaluate their relative effectiveness as weed killers and soil sterilants after the vegetation is growing. Treatments were made on June 6, 1963, at the time when Johnsongrass and most other weeds were 6 to 18 inches tall. In addition to most of the weeds present in the earlier experiment, the site chosen for this experiment included infestations of honeysuckle, fennel (Foeniculum vulgare), and spurge. All treatments were applied as broadcast sprays.

Table 1 Treatments and Weed Control Ratings from Spring Applications
Driver, Virginia, 1963

Herbicide	Form- ulation	Rate per Acre	Weed Control Ratings*			
			Broadleaf Weeds		Grasses	
			April 4	Aug. 14	April 4	Aug. 1
Monuron	WP	20	9	8	7	7
Monuron	WP	40	9	9	8	10
Diuron	WP	20	4	6	2	6
Diuron	WP	40	6	7	3	8
Dybar	G	40	2	4	0	1
Dybar	G	80	3	9	1	7
Hyvar	WP	10	8	9	8	9
Hyvar	WP	20	9	10	9	10
Hyvar	G	20	7	10	8	10
Hyvar X	WP	10	8	9	8	9
Hyvar X	WP	20	9	10	9	10
Urox	LOC	20	8	4	8	2
Urox	LOC	40	9	8	9	6
Urox	G	40	2	8	1	6
Urox	G	80	3	9	2	8
Simazine	WP	20	2	3	1	2
Simazine	WP	40	3	5	2	3
Simazine	G	40	1	5	1	3
Atrazine	WP	20	9	8	8	5
Atrazine	WP	40	10	9	8	8
Atrazine	G	40	8	9	6	8
Ureabor	G	435	3	6	3	5
Ureabor	G	870	4	9	5	9
Chlorea	G	650	8	8	6	8
Chlorea	G	1,300	8	10	9	9
Baron	e.c.	20 gal.	8	2	9	2
Baron	e.c.	40 gal.	9	7	10	5

* Weed control rating scale is based on 0 = no control and 10 = complete control.

The results from these summer applications, as observed on September 19, are summarized and shown in Table 2. The only treatments which gave rapid and complete control of most existing vegetation and continued satisfactory through the season were: Prometone at 20 to 40 gals/A, with or without Atrazine or TCA; Urox, at 40 lbs/A; Baron, at 20 to 40 gals/A; and Tordon + TCA, at 8 lbs/A + 50 lbs/A. All other treatments gave poor or only temporary control.

Atrazine controlled most broadleaf weeds and annual grasses very well, particularly at 40 lbs/A, but had only fair or minor effects on trumpet vine, honeysuckle, fennel, Johnsongrass, and Bermudagrass when already well established. These same species were also the most difficult to kill with other herbicides. If only one broadleaf species survived it was usually trumpet vine, while Johnsongrass was generally the most resistant grass. This was also the case in the spring experiment.

Tordon was so effective in eradicating all broadleaf species that further testing should probably be done at lower rates of Tordon, in combination with higher rates of TCA and perhaps other grass killers. Further observations in 1964 will be made to determine the relative residual effectiveness of Tordon and the other promising materials as soil sterilants.

Summary and Conclusions

1. Early spring and summer applications of several commercial herbicides were made to evaluate their comparative effectiveness as soil sterilants and general weed killers under characteristic conditions of eastern Virginia.
2. With the exception of Baron and other short residual materials, the herbicides were more effective applied in early spring than when applied to weed foliage.
3. Early spring treatments which gave good control of existing vegetation throughout the first season were Hyvar, Hyvar X, Chlorea, Monuron, Atrazine, Ureabor, Urox, Dybar, and Diuron.
4. With the exception of Hyvar, Hyvar X, Chlorea, and Urox, both broadleaf and grass vegetation were satisfactorily inhibited by these herbicides only at the highest rate used.
5. Atrazine has been consistently superior to Simazine as a soil sterilant in eastern Virginia.
6. Monuron has also generally given slightly better control than Diuron.
7. Hyvar and Hyvar X are extremely promising for complete and long lasting soil sterilization.
8. Of the herbicides applied to growing vegetation in the summer, only Prometone, Urox, Baron, and Tordon + TCA gave complete kill and satisfactory residual control throughout the season.

9. In both experiments, the most resistant broadleaf weed and grass were trumpet vine and Johnsongrass, respectively.

10. Other commonly existing species which were difficult to eradicate include Bermudagrass, nutgrass, fennel, honeysuckle, plantain, and dock.

11. Further observations and data will be taken during 1964 to determine the relative longevity of control from the more promising treatments in both experiments.

Table 2 Treatments and Weed Control Ratings from Summer Applications
Driver, Virginia, 1963

Herbicide	Rate per Acre	Weed Control Ratings*(Sept.19)	
		Broadleaves	Grasses
Atrazine	20 lbs.	5	2
Atrazine	40 lbs.	7	6
Prometone	20 gals.	9	7
Prometone	40 gals.	10	9
Urox	20 lbs.	5	4
Urox	40 lbs.	9	8
Urox J	80 gals.	1	2
Urox J	160 gals.	4	4
GC - 7887	1 gal.	1	1
GC - 7887	2 gals.	5	2
HCA	6 gals.	1	2
HCA	12 gals.	2	4
Baron	20 gals.	10	7
Baron	40 gals.	10	9
Garlon	6 gals.	5	2
Garlon	12 gals.	5	3
Prometone + Atrazine	20 gals. + 20 lbs.	9	8
Prometone + TCA	20 gals. + 25 lbs.	9	8
Tordon + TCA	4 lbs. + 25 lbs.	10	5
Tordon + TCA	8 lbs. + 50 lbs.	10	8

* Weed control ratings scale is based on 0 = no control and 10 = complete control.

A NEW HERBICIDE, 4-AMINO-3,5,6-TRICHLOROPICOLINIC ACID,
FOR BRUSH CONTROL IN THE NORTHEASTERN UNITED STATES

R. A. Schwartzbeck and Mark G. Wiltse¹

Introduction

Chemical control of undesirable woody plants on both public and private utility rights-of-way has been an established practice for many years. Herbicides used in these programs have been mainly 2,4,5-T and 2,4-D. While these programs could be considered successful, it has been found that in some cases certain species are partially resistant to these herbicides and thus frequent retreatment or special control methods have been necessary. Recognizing this limitation, The Dow Chemical Company has for many years conducted an intensive research program in the area of woody plant control.

This extensive research program in woody plant control was justified recently when a highly active new brush killer was discovered. Chemically, this compound is 4-amino-3,5,6-trichloropicolinic acid and is known universally by the Dow trademark Tordon. This compound has demonstrated its effectiveness in many laboratory and field experiments conducted throughout North America. Tordon herbicide promises to overcome many of the limitations of commercial brush killers available up to now and should be a useful tool for more efficient brush control in the Northeastern United States.

Exploratory testing with this herbicide by our own personnel on a wide range of woody plants growing in pots and in a woody plant nursery revealed that this compound could be very useful because of its activity at low concentrations and effectiveness on many species. (1, 2, 3)

After the exploratory work was completed, field plots were established throughout North America to evaluate more fully under varying environmental conditions, specific dosage rates, optimum application times and possible mixtures of Tordon plus other herbicides for treating the many species composing the brush problem on industrial rights-of-way. (4)

Results which will be presented in this paper are some of those obtained in experiments conducted by Dow research personnel in the northeastern region of the United States. The results of experiments on rights-of-way brush control conducted in the Southern United States will be presented at the 1964 Southern Weed Conference by H. A. Nation and C. T. Lichy².

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²Plant Science Research and Development, The Dow Chemical Company.

Materials and Methods

Sites were selected for establishing experiments on electric utility transmission rights-of-way to obtain a range of species that was representative of the current brush problem in the area. These locations were chosen on the basis of a uniform stand of brush, 6 to 8 feet high, with as many different species as possible.

Sprays were applied in early June at the time the brush was actively growing, and observations were made throughout the balance of that year and the following year's growing season. Fifty gallons of spray solution of each treatment was applied to duplicate plots as a leaf-stem (foliage) spray to thoroughly wet the leaves, stems and root collar area of brush species that normally interfere with line and right-of-way maintenance. The sprayed plot was then staked and measured and the spray volume per acre actually applied was calculated. The spray volume used ranged between 185 and 400 gallons per acre depending on the brush density and height.

Tordon herbicide as the triisopropanolamine salt was applied at several concentrations alone and in combination with other brush killers. The treatment of 2,4,5-T* at 4 pounds per hundred gallons water was used as the standard at all locations.

An experimental area was established in cooperation with the Virginia Electric Power Company near Richmond, Virginia, on a 100 foot transmission right-of-way. The line had been cut 5 years before and had been foliage sprayed 3 years before the experiment was applied with a spray mixture of 2,4-D and 2,4,5-T at 2 pounds of each plus 10 gallons of oil in 90 gallons of water. At the time of spraying leaves had fully developed on all species. The clay loam soil varied from well drained to poorly drained in some low spots. Sprays were applied with a high volume power sprayer using a quick shut off adjustable spray gun with a number 7 spray disc. The major species recorded at the time of spraying were as follows: Oak, white (Quercus alba); Oak, swamp white (Quercus bicolor); Oak, Southern red (Quercus flacata); Maple, red (Acer rubrum); Poplar, tulip (Liriodendron tulipifera); Gum, black (Nyssa sylvatica); Gum, sweet (Liquidambar styraciflua); Bay, sweet (Magnolia virginiana); Persimmon (Diospyros virginiana); Sumac (Rhus glabra); Pine, loblolly (Pinus Tadea); Cherry (Prunus sp.); Hickory (Carya glabra); Locust, black (Robinia pseudo-acacia).

Another experimental area was established in cooperation with the Consumers Power Company and Alpena Power Company near Alpena, Michigan, on a 100 foot transmission right-of-way. The area had been cut 5 years before treatment and had not been treated previously with herbicides. The area of sandy loam soil varied from

*Esteron® O.S. herbicide which contains 4 lb./gal. of 2,4,5-trichlorophenoxyacetic acid as the propylene glycol butyl ether ester was used.

well drained to poorly drained in a low area. Sprays were applied with a high volume power sprayer using a quick shut off adjustable spray gun with a number 7 spray disc. Most of the brush species were 6-12 feet tall and had completed full leaf development, except the oak species, at the time of spraying. The major species recorded at the time of spraying were as follows: Balsam (Abies balsamea); Maple, sugar (Acer saccharum); Alder (Alnus rugosa); Birch (Betula papyrifera); Hickory (Carya glabra); Hawthorn (Crataegus sp.); Spruce, white (Picea glauca); Pine, white (Pinus strobus); Aspen, large toothed (Populus grandidentata); Balm of Gilead (Populus gileadensis); Aspen, quaking (Populus tremuloides); Cherry, black (Prunus serotina); Oak, red (Quercus rubra); Sumac Rhus typhina); Willow (Salex nigra); Cedar, white (Thuja occidentalis); Elm, American (Ulmus americana); Ash (Fraxinus sp.).

An experimental area was also established in cooperation with the Central Maine Power Company on a transmission line right-of-way near Westbrook, Maine. The brush on this line had been cut 3 years before and basal stem treated 2 years before the experiment was applied using 2,4,5-T at 16 lbs./100 gallons of oil. This area was gently rolling with a well drained silty clay loam soil. Sprays were applied using three gallon knapsack sprayers in June after full leaf development. Brush was 3 to 6 feet tall when sprayed. The major species recorded at the time of spraying were as follows: Oak, red (Quercus borealis); Oak, white (Quercus alba); Maple, red (Acer rubrum); Juniper, ground (Juniperus sp.); Cherry (Prunus sp.); White pine (Pinus strobus); Alder (Alnus sp.); Balsam (Abies balsamea); Birch, gray (Betula populifolia); Aspen (Populus balsamifera).

Treatments were evaluated at all three locations during the season of application to determine top kill, foliage response, etc. Plant response ratings were made at the end of the second growing season following treatment. The following plant rating system was used:

- 1 = No effect
- 2 = Less than 50% top kill
- 3 = More than 50% top kill
- 4 = Top kill with root or root collar sprouting
- 5 = Top kill with no resprouting, dead

Each stem or clump was evaluated and the percentage of the plants showing each response was determined.

Results and Discussion

Leaf kill was not as uniform nor as rapid on some species with sprays of Tordon herbicide as with sprays of 2,4,5-T and 2,4-D. Some oaks and sweet gum retained green leaves for several months following spraying with Tordon. Combination sprays of Tordon herbicide with phenoxy compounds gave uniform leaf kill earlier than Tordon spray used alone.

Although leaf kill was slow on a few species, top kill and root kill occurred very rapidly on most other species. It is common to observe green or moist stems on most woody plants following sprays of 2,4-D and 2,4,5-T during the season of application. However, where Tordon was applied on species such as aspen, locust and maple the stems and roots were decaying within 3 months following spraying. By fall many of these plants were in an advanced stage of decomposition and could be easily pushed over or pulled out of the ground. When observed the spring following treatment, many plants had blown over or were broken off at the ground level by the snow and ice. Some of these undoubtedly were missed in the final counts.

Sprays of Tordon herbicide gave excellent kill of coniferous species when observed during the year of treatment. Twisting of the terminal growth was pronounced within 2 to 3 weeks following treatment. Later the needles turned yellow and finally reddish brown and on some species dropped off the branches. White spruce retained green needles for several months following treatment but the needles could be easily stripped from the branches at the end of the season.

The results, as shown in Table I of the plant response ratings of several coniferous species, show that in the case of white pine and balsam fir, Tordon at 0.7 lb./100 gal. produced a 100% kill while 2,4,5-T produced only 20% kill of white pine when evaluated two growing seasons following treatment.

Ground juniper and white cedar were easily killed with Tordon at 0.4 lb./100 gal. while in the case of ground juniper, 2,4,5-T killed only 9% of the plants.

Species such as spruce, slash pine and Virginia pine occurred in limited number and distribution and were not listed in Table I but were killed with Tordon at 0.4 lb./100 gal. Several species such as loblolly pine, shortleaf pine, slash pine and red cedar were killed with Tordon sprays at 0.7 lb./100 gal.

Root sprouting species have been a continual problem on rights-of-way in the Northeastern United States. Spraying with conventional herbicides often gave good top kill but root sprouting was prolific even during the season of application. Tordon herbicide has given outstanding control of all root sprouting species in tests throughout the country.

Plant response ratings recorded in Table II show that both aspen and sumac were completely killed with Tordon at 0.4 lb./100 gal. while 2,4,5-T at 4 lb./100 gal. produced a 90% and 40% kill, respectively.

TABLE I -- CONIFEROUS SPECIES

Percentage of Plants Showing Various Response Ratings
Two Growing Seasons Following Leaf-Stem Sprays*

Species	Plant Response Rating	Amount of Herbicide/100 gals. of Spray Mixture			
		Tordon 0.4 lb. ahg	Tordon 07 lb. ahg	Tordon/2μ-D 07 lb/20 lbahg	2μ5-T 40 lb. ahg
White Pine	1	14%	-	-	65%
	2	7%	-	-	-
	3	28%	-	-	15%
	4	-	-	-	-
	5	51%	100%	100%	20%
Balsam Fir	1	-	-	-	-
	2	-	-	-	-
	3	60%	-	2%	-
	4	-	-	-	-
	5	40%	100%	98%	-
Ground Juniper	1	-	4%	-	91%
	2	-	-	-	-
	3	-	10%	2%	-
	4	-	-	-	-
	5	100%	86%	98%	9%
White Cedar	1	-	-	-	-
	2	-	-	-	-
	3	-	-	-	-
	4	-	-	-	-
	5	100%	100%	100%	-

TABLE II -- ROOT SPROUTERS

Aspen	1	-	-	-	-
	2	-	-	-	-
	3	-	-	-	1%
	4	-	-	-	9%
	5	100%	100%	100%	90%
Sumac	1	-	-	-	20%
	2	-	-	-	-
	3	-	-	-	-
	4	-	14%	20%	40%
	5	100%	83%	80%	40%

*Plant Response Rating System

1) No effect, 2) Less than 50% top kill, 3) Greater than 50% top kill, 4) Top kill - resprouting from root or root collar, 5) Top kill - no resprouting, dead

Other root sprouting species were controlled but the stand was not sufficiently uniform to present comparative data in this table. Black locust, sassafras, chokecherry and persimmon were all 100 per cent top killed with no resprouting with Tordon applied at .7 lb./100 gals. Some regrowth of these species was noted in the plots sprayed with 2,4,5-T at 4 lb./100 gals.

Brush species that resprout from the root collar are important on rights-of-way in the Northeastern United States. Table III shows the plant response of several root collar sprouting species to leaf-stem sprays of Tordon, Tordon plus 2,4-D and 2,4,5-T herbicides.

TABLE III -- ROOT COLLAR SPROUTERS

Percentage of Plants Showing Various Response Ratings
Two Growing Seasons Following Leaf-Stem Sprays*

Amount of Herbicide/100 gals. Spray Mixture

Species	Plant Response Rating	Amount of Herbicide/100 gals. Spray Mixture				
		Tordon 0.4 lb. a/g	Tordon 0.7 lb. a/g	Tordon/2,4-D 0.5 lb. / 2.0 lb. a/g	Tordon/ 2,4-D .7 lb./2# a/g	2,4,5-T ester 4 lb. a/g
Maple	1	-	-	-	-	6%
	2	-	-	-	1%	1%
	3	-	-	-	1%	5%
	4	-	-	-	9%	55%
	5	100%	100%	100%	89%	33%
Oak, red	1	2%	3%	-	4%	13%
	2	3%	6%	-	-	3%
	3	8%	4%	-	1%	1%
	4	23%	21%	-	10%	19%
	5	59%	66%	-	85%	64%
Oak, white	1	5%	2%	-	-	18%
	2	5%	4%	-	-	7%
	3	5%	4%	-	6%	4%
	4	43%	36%	-	12%	67%
	5	42%	54%	-	82%	4%
Ash	1	10%	-	-	-	-
	2	8%	4%	-	8%	4%
	3	16%	11%	19%	8%	4%
	4	49%	31%	19%	46%	26%
	5	17%	54%	32%	38%	66%
Sweet Gum	1	2%	4%	-	-	-
	2	3%	6%	-	-	-
	3	7%	4%	-	-	-
	4	62%	54%	-	20%	38%
	5	21%	32%	-	80%	62%

* 1) More than 50% top kill 2) Less than 50% top kill

One of the most troublesome and widespread root collar sprouting brush species is maple. Of these the most widespread is red maple (Acer rubrum), which often resprouts prolifically from the root collar following mechanical or chemical destruction of the top growth. In all experiments Tordon gave excellent control of this species of maple. Tordon at 0.4 lb./100 gals. gave 100 per cent kill with no resprouting while 2,4,5-T at 4 lb./100 gals. produced a 33 per cent kill and 55 per cent of the red maple species were resprouting from the root collar.

Species in the red oak and white oak groups were slow to respond to sprays of Tordon with green leaves evident on some plants throughout the growing season following treatment with Tordon. Combinations of Tordon and 2,4-D caused a more uniform leaf kill. Most plants had green stems in the fall following early summer sprays; however, the cambium layer was off-color, with streaks of dead tissue apparent. The plant response ratings made following the second growing season showed that Tordon sprays at 0.7 lb./100 gals. gave approximately the same percentage top kill with no resprouting as did 2,4,5-T sprays at 4 lb./100 gals. Combinations of Tordon plus 2,4-D gave 35 per cent top kill with no resprouting which was better control than with either Tordon or 2,4,5-T used alone.

Species in the white oak group were controlled more effectively with Tordon sprays than with 2,4,5-T. The combination of Tordon plus 2,4-D gave 82 per cent top kill with no resprouting which was considerably better control than where either Tordon or 2,4,5-T was used alone.

Ash has been a problem to control with leaf-stem sprays using conventional herbicides. The most successful treatment that has been available is the use of 2,4,5-T at 16 lb./100 gals. of oil applied as a basal stem treatment. Leaf stem sprays using Tordon have not given superior control of ash. Tordon at 0.5 lb. plus 2,4-D at 2 lb./100 gals. as a leaf-stem spray gave 62 per cent top kill with no resprouting which was similar to the control obtained with 2,4,5-T at 4 lb./100 gals.

Sweet gum was slow to respond to leaf-stem sprays of Tordon with green leaves persisting on some plants throughout the first growing season following treatment although severe twisting and distortion of the leaves was evident. Sprays of Tordon alone at low concentrations did not give satisfactory control of sweet gum; however, when used in combination with 2,4-D good control was obtained. Tordon at 0.7 lb. plus 2,4-D at 2.0 lb./100 gals. gave 80 per cent top kill with no resprouting while 2,4,5-T at 4 lb./100 gals. gave only 32 per cent top kill with no resprouting.

Most other woody plants were controlled effectively using Tordon at .4 lb./100 gals. One hundred per cent top kill with no re-sprouting was obtained with all rates of Tordon on the following species: black willow, peach leaf willow, gray birch, white birch, alder, hawthorn, cherry, red bud, hickory, balsam-of-Gilead. The ground cover following treatment was of considerable interest. Since the sprays of Tordon were directed at the tall growing woody plants that are the problem on commercial rights-of-way, the ground cover of grass was not sprayed and remained dominant. Where a high volume spray was directed at clumps, grass became the dominant vegetation the first year of spraying. Several species such as greenbriar (Smilax sp.), American Holly, glossy privet and wild huckleberry were not killed by the sprays of Tordon.

In areas where heavy stands of brush had prevented grasses from becoming established before treatment, annual weeds and flowers were dominant following treatment with grasses starting to grow in the treated areas. Partridge pea (Cassia fasciculata) being both colorful and excellent wildlife food was one species that was dominant following spraying. Giant ragweed (Ambrosia trifida) also covered some of the experimental plots.

Where the brush was not dense, some of the ground cover species received only a portion of the spray. In these areas, many of the low growing shrubs and plants such as huckleberry, blueberry, dogwood, wax myrtle and brambles were not killed and became dominant following spraying. Poison ivy was controlled in all plots receiving sprays of Tordon.

Studies on the use of Tordon herbicide in helicopter spray applications and as a pellet for soil application have shown promise and are being continued.

Summary

Most woody plant species that are common on rights-of-way have been killed using leaf-stem sprays of Tordon at 0.4 to 0.7 lb./100 gals. In some instances sprays using combinations of Tordon plus 2,4-D have been more effective on certain species and have given more uniform leaf kill.

Tordon herbicide has given excellent kill of coniferous and root suckering species and has been shown to be particularly effective for the control of maple, elm, cherry and hickory.

Sprays with Tordon plus 2,4-D gave more top kill with no resprouting of red oak, white oak and sweet gum than did 2,4,5-T. Ash was less susceptible to sprays of Tordon than to sprays of 2,4,5-T. By applying sprays of Tordon to the tall growing woody plants in scattered stands of brush many of the low growing plants were maintained. Also several low growing shrubs were found to be resistant to Tordon sprays. Annual weeds, flowers and grasses soon became established in areas following treatment with Tordon making the area desirable for wildlife, preventing erosion from occurring, providing a habitat for desirable insects and with the rapid decomposition of the woody plants made it acceptable to the power companies and esthetically acceptable to the general public.

Literature Cited: 1. Down to Earth, Vol.19, No.3, Winter, 1963, 2. Science, Vol.141, July 26, '63, 3 and 4. Down to Earth, Vol.19,

The Delaware Demonstration
Robert J. McMahon and Thomas J. McMahon

In the Fall of 1963, one side of all the roads, except urban streets, in the State of Delaware were treated with recommended amounts of the synthetic auxins, 2,4-D and 2,4,5-T. The opposite sides of all the roads were not treated. Where there was a center mall, one half of the center was treated.

The purpose of the treatment is to demonstrate the validity of the benefits to be gained from proper use of roadside sprays as listed in Cornell University Bulletin 821, published in 1957. The suggestion to make this demonstration had been made at least five years ago, but it was felt that such a demonstration was not needed. This was the opinion of many leaders. We, however, from grass roots experience with the public, felt that those at the top did not realize the job to be done if the public was to secure a sound concept of this field.

When, into this public opinion vacuum, the emotional presentation of "Silent Spring" appeared, these forces of doubt and suspicion were presented with what they needed to give authority to their fears. In Binghamton and Broome County, one woman secured 250 signatures on a petition calling for the end of the use of "poisons." As she placed her petition before the Broome County Board of Supervisors, she then dramatically threw Rachel Carson's book before them and said, "And there is our reason." Another woman from the Town of Vestal secured approximately 150 signatures.

The industry had appropriated a quarter of a million dollars for leadership education to combat this kind of opinion. This was an excellent program for what it was designed to do. But, as we saw it, the problem was not with leadership; the problem was with the public. The problem was with "followership." These were the people

These political leaders were elected At the time they had adopted this program, they had already been educated. As Mr. Ed Jones, Chief Maintenance Engineer said at Pennsylvania's Shwanee Meeting, "Don't tell me about your chemicals; I know all about them Go tell the public. If the public understands, I can use your chemicals. But I am an engineer, not a public relations man. You cannot expect us to do your job for you We want to use these chemicals; we know what they will do. But we cannot do anything which that public does not understand I do not see why you people do not see this simple point "

When we did the first massive roadside spray program in the Pocono Mountains, it was understood that we would conduct a program of education so that the public would understand what was being done. This we did with showing of film on WCAU-TV in Philadelphia, with color slides, with newspaper and radio releases, and by personal contact with the various civic associations in the Pocono area. We followed up with meetings showing the results.

A considerable part of our cost was this public education requirement. The pattern we followed in this introduction of weed control in the Pocono area of Pennsylvania, we followed also in every place we introduced this method of control. We used as source material all the findings of Cornell University, The Rutgers University, Ohio State, Wisconsin, Penn State, and elsewhere. We followed the findings of the Northeastern, the Southern, the Western, and the Weed Society of America Conferences Our source material came generally from these groups coupled with color slides and color films which we had taken in the course of our work.

In general, our program had received acceptance and we encountered

only occasional emotional flare-ups which generally came from inexperienced utility applications. Where utility programs had followed the judicious policies of the Vaupels there was acceptance.

When, however, confronted with an aroused dormant emotionalism which, regardless of the facts there on these women's own roadsides, we realized we must do something equally unscientific. We did have to contact all these women who signed the petitions and explain to them the facts. In fact, our sales efforts were stopped by this tortuous time consuming work. It was to provide other public officials with an immediate reply to people who placed credence in these best seller opinions that we sent to Miss Carson and her publishers the challenge to do one side of all the roads of Delaware according to standard recommendations and she to do the other side according to her recommendations. The benefits listed in the Cornell Bulletin 821 were to be the basis of judgment. The judges were to be from nationally recognized associations or government departments. If she, in the judgment of these men, was determined to be right, we would pay her all the money we had made from weed control. If, however, the method we employed was determined the reasonable method, then she was to pay us all the money she had made from her books during the same period.

Neither Miss Carson nor her publishers ever acknowledged receipt of that letter. The letter did, however, did provide many public officials with an effective rebuttal to upset women. "If she is right," they could now say, "why doesn't she answer this letter?"

The letter, therefore, was not just a publicity device. It was a carefully considered offer to force the evaluation away from the

Bahama vacationing gardeners back to the problem facing highway superintendents. The difference was: the former did not really know the real growth problems along a roadside. Once a year they passed them on the way from the Bahamas to Maine; the latter did know the problems of roadside growth from 365 days of sweating contact and they did know how to meet it. The problem was to force the Green Mantle girls to face up to their words.

The device was effective. We received no more petitions. But let us add, this was more than a device. In 1955, we weighed very carefully this question of selective application. Two tests were conducted. John McLaughlin of N. J. Bell ran one in South Jersey. Paul McMahon ran the other in Broome County, N. Y. Neither knew of the others efforts.

Two men were employed in each test. In the Paul McMahon supervised test, no smoking was permitted. Only time out for lunch was included as permissible omission. The men were required to do one mile to a width of eight feet. All brush was sprayed with a knapsack sprayer using the oil solution and the circumference of the brush at the root collar. The cost per mile by this method was determined to be at least 27 times greater than the controlled broadcast spray of the selective herbicide.

It was when we were discussing this test with N. J. officials that Mr. McLaughlin revealed he had conducted a similar test. He stated his study had revealed that the costs were not only exorbitant, but the results were not satisfactory. He said he had not told the men it was a test. He wanted to see what one could expect normally. He had then work for several weeks. The weather was hot. He said that their efficiency decreased with the passing hours. The knapsack

sprayers were too heavy. Every four or five minutes they had to be pumped up. "Within two hours," said Mr. McLaughlin, "the men were so tired they just did not care. They had many misses and the results increased in spottiness as the day grew longer."

Hence, we knew before we would ever start what the outcome would be. We would have welcomed Miss Carson's accepting our challenge, but we did not make the offer without a full background of knowledge. We think it is important that you know our thoughtfulness in this matter

That we are doing this Delaware Roadside Pesticide Demonstration regardless of Miss Carson's failure to respond is to be attributed to the persuasiveness of Mr. John Connell, New York Science teacher and President of his Rotary Club, who founded the National Council for the Control of Pesticides. He became aware of the Delaware proposal through James Corby who had considered the idea as a public relations project for Ansco, where he was Director of Public Relations.

The 11-man Delaware Highway Commission considered that such a Demonstration would be in the public interest and granted permission the National Council to go forward with the project. One side of all the roads were treated last Fall. The Fall start was made because tests show the best time to begin a program for turf development is the Fall. The second best time to start is early Spring. Delaware marks the third project we have started in the Fall. We mention this point, for we were surprised to have so many people ask us, "Do you think you will get adequate results with such a late start?" As early as 1953, tests showed superior turf development with this Fall start. Hence, this Delaware

Demonstration starts with an optimum scientific potential. We might have secured a more dramatic visual result immediately with a June or prior to Aug. 15 start. Effects would have been more visible, but the greater desired end has been served by the Fall start.

The first public announcement of the program was made the day it started September 17, 1963. The story was on Page 1 of the Wilmington "Morning News." Tom Malone who wrote the story injected the "Silent Spring" aspect. The original announcement made no reference to the letter offer of several months previous. It was desired to avoid controversy. As Robert McMahon stated, "We are not entering a controversy; we seek to end a controversy by demonstration."

Tom Malone, however, after asking a series of questions of Thomas McMahon at 6:30 p.m., later wondered what Rachel Carson would think of this program. Mr. Malone called her at her home in Silver Springs. When Thomas McMahon returned to his room at the DuPont Hotel at 9 p.m., there was a call from Mr. Malone. Mr. Malone stated he had called Rachel Carson. It was then that Thomas McMahon mentioned the earlier letter of Robert McMahon. In the page one story, it appeared Mr. Malone had called Miss Carson again. He wrote, "'Other than saying her book had shown no objection to roadside spraying under carefully controlled conditions, she said she would rather make no comment at this time."

Within two days, however, a Mr. Robert Burnap, listed as a Conservation Consultant, made his appearance in Delaware. He first appeared as an interested citizen. Later he appeared with the National Wildlife Federation representative and with the Dr. Egler group. The burst of public alarm at the announcement of the project caused Mr. William J. Miller, Director of Operations and Mr. John H.

McWilliams, Maintenance Engineer, were forced to request three stoppages in order to satisfy certain complaints or requests. By the time, the program was finally under way, it had been reviewed and approved by the Highway Engineer, the State Laboratory, the Health Department, the Conservation Department, the Board of Agriculture, the U. S. D. A. Extension School at the U. of Delaware, the Safety Engineer, and just about everyone possibly concerned. The chemicals, the equipment to be used, the area to be treated, the rate of application, the time of application, the personnel applying, and every possible factor to be considered were all approved privately in meeting with Mr. Miller and in the absence of representatives of the National Council or the applicators. It could finally be said that no roadside spray program had been so thoroughly and publicly scrutinized as was this program. No official charged with the responsibility by the public for decision had found reason to object. And never was any official so under the pressure of newspapers than these men. The stories occupied page one of morning and evening papers no fewer than 7 times in a three week period. Additionally, there were stories on inside pages and columns on the editorial pages.

These stories reflected a shocking ignorance of the basic issues by the reporters whose stories conveyed little of the scientific facts and everything of the alarm of the excited. In Dover, Del., Mr. Smythe, the publisher of the "Delaware State News" said when we asked him why the alarmist views had crowded out the facts, "I know what people like to read." Perhaps he gave us the key to this whole treatment.

The important thing is that Delaware public officials did

panic or yield to this combined emotionalism of scattershot scientists kept in orbit by circulation minded writers.

We do not disagree with these newspapers up to a point. Back in 1928 educators at Columbia University learned that students learn better when under an emotional stimulus. The I.Q. can be raised by a use of the rod, or by a reasonable substitute which will get the adrenelin flowing. Public Relations psychologists would do well to look at the handling of this Delaware Demonstration, for there is no population in the world which has had such a thorough indoctrination in the benefits of weed control chemicals. The newspaper approach had the effect of introducing an emotional stimulus, or of activating an existing emotional stimulus. The newspapers held back information, it is true, but they did do a terrific job of creating a maximum suspense. And the sale of papers must have received a great surge; otherwise, why would both papers keep the subject boiling for so long. The subject was so good that it moved the racial stories and South Vietnam and Madame Nhu back to page two. Such was the interest generated.

When after three stoppages had been caused the program was finally approved by all officials possible, a telegram was sent to the Governor asking that the program be stopped until the National Wildlife Federation and the Garden Clubs of America could bring in expert ecologists who would enlighten the highway officials on the proper course. The Governor would not deny the counsel of his proper officials, but he did request the highway officials to meet with this group. Accordingly this group was given an audience

They met at two o'clock one afternoon in the Highway Commission Meeting Room at Dover. We were invited to attend. Dr. Frank Egler who was mentioned in Miss Carson's book was introduced as the authority who would counsel the highway department. We remained until it became clear there was no valid objection to what we were doing. The only question was what would this group do which would be better. To make possible total freedom in their presentation, we requested to be excused.

Whether this group will present a plan for treating the other side of the road in the manner recommended by Miss Carson or suggested by her, we do not know. The Delaware State Highway Commission has stated that they will not refuse any reasonable presentation by any group which believes it has a better way to meet this problem. In fact, in our presence, Mr. John McWilliams and members of the Commission stated this policy to the representatives of the National Wildlife Federation and the Garden Clubs of America, which group included, one noted, Robert Burnap who had appeared two days after Mr. Malone's kick-off story.

Near the end of this Delaware debate, the course of affairs took an unexpected twist. New complaints began to come in. The new complaints were, "How come you are spraying Smith's side of the road? What do you have against me?"

"You know," said Engineer John McWilliams, "You guys may not be so crazy, after all. If these complaints keep coming in, we may be forced to spray the other side. You could lose your comparison study. The people on the other side may not stand still."

Delaware State

"The public is funny," said Public Relations Director, F. X. Splane.

"This is one I could not figure out. Several times I thought it was dead. It looked like an impossibility. But now it appears that it was just a small segment making a lot of noise. But now we have a big segment making a lot of noise, except that the big segment has gone your Cornell's way."

This is the story of the Delaware Roadside Pesticide Demonstration to date. It is a story of a principle of public relations which seems to substitute demonstration to present to the public and to the newspapers and radio and television a fundamental image of the integrity of the combined scientific industrial governmental activity in the exploration, investigation, adaptation, approval, and adoption of new and valid scientific truths in the public interest. It is a principle which seeks to avoid controversy by massive demonstration in a place and in a manner which the public can understand, and in a manner which cannot be twisted without full public awareness. It is a principle which seeks to encourage the open, forthright courageous action the public looks for in its leaders whether in science, business, or industry. It is a principle which avoids imaginative or one-sided imbalance in what must be objective presentation.

You are invited to go see the Delaware Roadside Pesticide Demonstration, but you are asked to remember that the roadsides are only the result of a chemical application. You must see this whole chronology fully to see what has happened in this Delaware Demonstration. It is a demonstration of a principle at work. It is a principle which invites your inspection, examination, and support. This support is needed if this principle is to find further expression.

POLYGONUM CUSPIDATUM SIEB. AND ZUCC., JAPANESE KNOTWEED¹A. M. S. Pridham²

Polygonum cuspidatum, native to temperate East Asia (9), is a perennial from Japan, 1825 (8), noted in 1879 (3,8) as "a plant of sterling merit, now becoming quite common----and undoubtedly one of the finest herbaceous plants in cultivation." The hollow brittle stems reach a height of 6-8 feet by mid summer in New York State. Small greenish white flowers 1/8"-1/4" paniced racemes are conspicuous in September till frost. In 1963 early spring growth was killed May 24 by frost (28°F) and summer growth terminated as it did for corn with a sharp frost, September 14.

Bailey (1) in 1924 reports this plant as "now common in yards and also somewhat escaped." Muenscher (6) in 1955 says of Japanese knotweed, "Perennial, reproducing by long stout rhizomes, also by seed. An escaped ornamental; waste places and neglected gardens; spreading rapidly and becoming obnoxious." Muenscher gives a good line drawing of Japanese knotweed showing the stout rhizomes, longitudinally rolled young foliage and the squared off base of the typical leaf. He also shows the flowers and a typical seed.

Salisbury (8) 1961 states, "We can see it on waste ground in London clearly resistant to atmospheric pollution and able to grow on very poor soil; once established, however, it is a labour to eliminate. This remark applies with even greater force to a similar but larger species (P. sachalinensis (2, 4, 9) from the Island of Sachalin. This can grow 10-12 feet high and has a similar appearance, but is most readily distinguished by the larger oval leaves, sometimes a foot long, and the two accessory glandular depressions on both sides of the central one. It was introduced in 1869."

Salisbury ends his discussion, "The spread of these knotgrasses is mainly due to growth of the stout rhizomes which are sometimes so tough as to require the use of a saw." This remark will find many seconders among the letters from New York State gardeners who have tried to "grub it out."

Muenscher pointed out Polygonum cuspidatum to the author as a good one to explore in evaluating 2,4-D (1946-47) and some tests were made. The usual epinasty was observed and the plants continued to live. Later CIPC and Amino Triazole were used without spectacular results. During 1959-60 more inquiries than usual were received and in 1962 a patch of P. cuspidatum was located and treatments begun, as basal spray, in late June on the thesis that carbohydrate reserves would be low during rapid growth and that herbicides of hormone type might be translocated into the root sections without killing the foliage and thus releasing more bud break; also spray drift could be

1. Merrill, E. D. 1938. A critical consideration of Houttuyn's new genera and new species of plants 1773-83. *Journal of the Arnold Arboretum* 19: 291-375.
2. Professor, Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, N. Y.

minimized and translocation of herbicide increased. Preliminary tests with rhizomes of quackgrass, Agropyron repens L., and of Artemisia vulgaris L. pointed toward Amiben, Fenac, Prometone, Silvex (2,4-5TP) as worth trial on Polygonum. In 1962 (7) tests pointed to Fenac as reducing growth and distorting foliage both in 1962 and holding over through winter to modify 1963 growth without further treatment. Soil sterilants at high rates of active ingredient per acre were reported by Sylwester and Bakke (10) for control in Iowa plots, 1958.

Treatments in 1963 included Fenac, 5 pounds aia and 10 pounds aia per 100 gallon spray. Benzac, Banvel D, UC 22349, N3291, Amino Triazole and lastly two formulations of Tordon (22K) (101), these last at 1, 2, and 5 pounds aia, both as basal spray, as foliar spray and in combination with UC 22349 or with Amitrole in one location (Richford, N. Y.) during July 1963. Limited tests were made in three additional locations (Niles, Ithaca, and Richford, N. Y.); ranging from June to September. Root sampling was begun 2 weeks after treatment. Exceptionally consistent results were found with Tordon at application levels of one to three pounds aia/100 gallons/acre basal spray. Action continued after frost, September 19. Killed the foliage as it did with corn. Growth usually continues through October.

Young stolons or rhizomes show surface discoloration, browning and decay. Buds in the crown section show early discoloration and later death and decay within 30 days.

Older rhizomes starting at the crown of the plant or base of the 1963 shoots show excessive callus bulging through the brown outer bark in ridges of hair width to 1/16-1/8 of an inch and varying in length. In some cases the surface of the rhizome or root becomes soft; the central pith, too, becomes discolored (orange), softens and decays.

In two plots separated by several miles the late summer foliage remained green 1-3 weeks after treatment. Underground parts were largely normal but by late October and without green foliage or green stems, symptoms of root and bud damage had progressed to the point that normal buds were rare and the surface of most roots soft with discolored pith. The stem near the ground showed excess callus in raised areas.

When root samples were placed under mist in the greenhouse, October 15 through November 15, controls produced young shoots with normal foliage. Fenac treated plants produced shoots showing typically distorted foliage. No growth was found on roots from Tordon treated samples. The results are therefore promising in so far as control of P. cuspidatum is concerned.

Other effects are important. Direct sprays of 1/32 pound aia/100 gallons on Juniperus horizontalis in August discolored all 1963 foliage. 1962 foliage is normal or dead (one pound aia) level. Taxus cuspidata was killed when one pound aia spray was used. Euonymus fortunei and Forsythia intermedia as well as Artemisia vulgaris are all sensitive to direct spray.

Tordon used outdoors in July-August has not disturbed garden flowers 50 feet away, but has modified growth of sugar maple, lilac, and forsythia when the roots of these plants occupy the same soil as the treated Polygonum

cuspidatum. In this particular case the drainage field from a septic tank; most soil even in a dry summer.

Within present experience Tordon at low rates has given outstanding kill of roots and basal buds of P. cuspidatum from a single treatment basal spray applied only to run off. Late summer and fall treatment of young regrowth foliage from June-July cutting is also effective and possibly the most practical treatment for highway and garden conditions.

In summary, Tordon (picolinic acid formulation) in first tests has been exceptionally effective at one pound aia or less as basal spray or foliar spray on mature or on young foliage. Many ornamental plants are also modified or killed certainly by direct spray and by other contact. Hand sprayers at 20-25 psi used after the first flush of growth in a dry summer offer one method of application for home owners and for others operating to control Polygonum in other than waste places. Sprayers need 2,4-D type cleaning in present experience.

aia - active ingredient per acre

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"CHEMICALS FOR HIGHWAY ROADSIDES ONLY, TO ASSIST IN
REALISTIC RESTORATION OF NATURE".
JOSEPH L. BEASLEY¹.

The title of my paper today, "Chemicals for Highway Road-sides only, to assist in realistic restoration of nature", in my opinion is one of the most challenging issues to be conquered by the Chemical Industry, Highway Engineers, Landscape Architects and Highway Landscape Supervisors, in the construction of new highways throughout the United States.

The challenge being whether we continue to use the same passive techniques of 25 years ago, or introduce and incorporate new methods in the development of the Nation's new highway systems.

The preservation of natural growth and natural vistas must be increased and not allowed to disintegrate into sparsely landscaped areas. However, many fail to accept the modern techniques in chemical research which could, by cooperative development and guidance, provide the strongest combatant to the ever increasing costs of roadside management.

I believe each and everyone attending this conference realizes and appreciates by experience the basic and elementary fact that nature disturbed must of necessity be effectively restored.

In the design and construction of new highways, it is fundamental that every effort must be directed towards the preservation of all natural growth paralleling the highway. This is not only sound economically but avoids expensive replanting and every landscaper knows that the natural scenic qualities of the countryside cannot be entirely reproduced. Not only is the planting of trees and ground covers a suitable and adequate approach for the blending into a naturalistic state but it contains the economic advantage of reducing maintenance costs. However, the planting of grass is not always necessary and in my judgement is considered in the category of passive landscaping. Initially, it is far cheaper to suffer the cost to plant seedlings, vines, and other ground covers than to bear the enormous expense of mowing grass for generations. In my opinion, there is no question that grass develops faster and to some extent serves its purpose. However, it must be remembered that the fertilization, loaming and reseeding of grass increases the roadside budget and the mowing costs continue for years. Given the element of time, 1 to 2 years, and using a liquid fertilizing program the plantings of seedlings, woody shrubs and vines

¹Highway Landscape Supervisor, Massachusetts Department of Public Works.

will develop with the aid of wood chip mulch into a decidedly more naturalistic highway and moreover eliminate the mowing of grass forever. The above mentioned materials using "Root through Pots" together with sufficient fertilizer and suitable soil should be utilized in difficult areas to mow and on slopes having existing soil, thus, giving them a strong foundation toward a healthy development.

Communities must become more conscious of the necessity for stronger controls of land usage within their jurisdiction. They must contribute to the formation of Parks for regulated recreation, wooded areas for groves and picnic areas and some sections for wild life propagation. Any limitation in the foresight of those public officials entrusted with civic administration will be an injustice to future generations.

In the design and construction of new highways, it is a fundamental principle that maximum effort be directed towards safety and the preservation of all natural growth possible off the traveled way. This is not only an economic consideration to avoid expensive replanting, but, again I repeat, it is a landscaping maxim that the natural scenic qualities of our countryside cannot be entirely reproduced. Also, not only is the planting of trees and ground covers a reasonable reversion to a natural state but, as well, it has the economic advantage of reducing maintenance costs.

Our consideration in treatment of roadsides could not be completed by merely achieving a beautiful contrast of green and black. Nature's demands are not satisfied by any ill-fitting graft on her scars. Our travelling public and tourist industry insist upon retention or near perfect reproduction of Massachusetts' beautiful scenic qualities.

We in Massachusetts, have in the last three (3) years, in the roadside development of our new highways, placed the following materials:

Shade Evergreen and Flowering Trees:	56,438
Seedlings, Pines and other evergreens:	310,280
Evergreen shrubs:	87,540
Deciduous shrubs:	50,760
Small woody shrubs, vines:	541,755
Sods of blueberry, sweet fern, natural growth:	448,750
Wood chip mulch:	103,627 cubic yds.
Shingle-Tow mulch:	3,700 tons
Hay mulch:	3,349 tons

While this appears to be a tremendous amount of planting material, it is only 30% of the total needed for replacement in the stripped roadside areas.

Trees, woody shrubs, and vine cover plantings are a prime consideration not only in new construction but in the maintenance of older highways, as well. We pursue annual maintenance programs of tree planting, tree trimming, tree removal of the dead and diseased, selective clearing, chemical spraying for the eradication of weeds and undesirable brush, etc. All of this is for the protection and furtherance of what we have on our picturesque roadsides, to satisfy both the aesthetic and practical purposes outlined above.

Plus, during the last 8 years, we planted 14,000 trees under our maintenance tree planting contracts. In the last 5 years, 200,000 seedlings, pines and other evergreens have also been planted in this program.

In spite of the fact that our present 2500 miles of State highway includes 20,000 acres of roadsides for maintenance (10,000 acres in the last 12 years have been eliminated from mowing costs substituting natural growth and planting materials through the inducement of nature) we feel much more could and should be done by our Highway Department in securing and preserving in their natural state, many more adjoining land areas. Such valuable, untouched, wooded sites will be sorely needed by future generations for solace and relaxation. Our Right-of-Way takings have increased in 20 years from 50 foot widths to lateral expanses of 400 feet.

Although this is principally to provide for modern highway design standards and to insure additional land areas for future widening, there is also the partial purpose of providing permanent havens for native growth. Certain qualified sections are, or will be, developed as rest areas or scenic vistas to accomodate the weary traveller or those in pursuit of a realistic enjoyment of nature. We should be strengthening and enlarging this program by taking much wider layouts initially and making spot widenings of existing layouts to capture irreplaceable sites with surroundings of natural quality and views which defy duplication. Once gone, permanently marred, or destroyed by development or industrialization, it will leave us cloaked in history as having been shamefully remiss in our obligations.

The maintaining of the balance of nature in highway construction is a natural law and certainly not a luxury.

Roadside development is not adhering to this new chapter in history, namely, "The Space Age".

Where are these scenic highways that we have promised to leave as a heritage for future generations?

A few have been constructed - but - I repeat, "Very few". The vast majority of the roads are still utilizing passive methods in the landscaping employed, grass, grass, and more grass.

We must initiate a new concept in approaching the many and varied problems contained in roadside maintenance.

The initial cost is not fully comprehended by many of us present today; we unconsciously overlook the continuing, ever mounting maintenance costs in the construction and maintenance of our highways. There is much more involved in maintenance today, than many engineers realize. No longer does maintenance include only the plowing of snow, sweeping of sand and mowing of grass. Those days are gone forever.

Each individual highway must be designed in a tailored fashion according to the dictates of the surrounding terrain. The construction plans must include not only a complete highway, but, one including the many and varied facets of built-in-maintenance. In many instances, the engineering costs for the preparation of roadside plans are far above the planting materials budget. This is unnecessary and should be, to some degree, modified.

Now, we have before us the vast latent advantages of modern chemical techniques. We are neither the serfs nor the masters of the chemical industry but, our mutual dependence, that between manufacturer and markets, could produce a cooperative effort to the inestimable benefit of us both. They must begin to appreciate the measure of our roadside maintenance problems and contribute at realistic cost the synthetic materials and equipment necessary to overcome our present maintenance burden. We must, likewise, be prepared to assist and accept their advances since, without some demonstrative financial encouragement, their goal is hopelessly obscured and unattainable.

A program by States and Municipalities to assist in this development by demonstration of needed interest and to encourage production by a willingness to experiment, should not be construed as a crusade for subsidization of the chemical industry. It should rather be considered in the realm of promoting consultants whose fruits of labor, however short of perfection temporarily, should be capitalized upon. To wait for the industry's development of the perfect inexpensive solution to every particular roadside problem is only hiding our proverbial heads in the proverbial sand. That kind of financing just doesn't exist and that kind of research gamble should not be expected.

Development of better materials at better cost will only come with our contributions. The more money which we can eventually save on maintenance will not only be an earning for the taxpayer but will afford us more capital for greater or more extensive improvements.

The Chemical industry today is bypassing our potentially prolific market, and we are partially to blame by our lack of inducement. However, the fault doesn't lie wholly with us. It behooves the industry to recognize and give sufficient consideration to the needs of highway roadside management. This would require their turning away to some degree from the presently lucrative markets of the commercial growers. The profit margin in selective agriculture understandably affords a more readily determinable inducement to chemical research and production. But we can't be expected to accept for our needs expensive modifications of developments which were designed to benefit commercial interests nor be expected to compete by guarantees for what we feel is necessary and within scientific reach at moderate cost.

Our potential, large scale use of effective chemical products warrants private expenditure in research and development. The chemical industry must be willing to gamble to some extent on future returns if we show a reasonable desire to cooperate. Again, however, I reiterate, the initiative must be shown by industry through pure study of roadside needs not by offering adaptable derivatives of what has proven profitable in other fields. Roadside development in chemical science is too great an area to be treated as a possible outlet for by-products. Each year as more miles of roadsides are added to our maintenance concern, thousands nationally, the problems of their management magnify the quest for more efficient controls. The most expeditious time for instituting chemical pursuit of this burgeoning problem is now.

The Massachusetts Department of Public Works, in cooperation with the Bureau of Public Roads, is conducting a research program at the University of Massachusetts for better avoidance of grassing areas by planting natural growth and restoring the balance of nature. In this and many other ways, there has been accumulated research data which could be of extensive benefit to the chemical industry, but industry has not come forth to make use of this available information.

Here, then, as follows, are some very vital and desirable subject matters for chemical study and production. Provision of reasonable assistance with these problems by industry would be economically justified.

(a) a safe chemical sufficiently selective and easy to handle to eliminate grass or weed growth around but without injury to tree or shrub plantings.

(b) a good stimulant in the form of a balanced liquid fertilizer, hormone, or enzymatic chemical, which can be sprayed without injury to plant life and which will accelerate the growth of seedling pines, other evergreens, woody shrubs, low bush blueberry, bearberry, sods, vines, etc.

(c) a less expensive chemical to retard the growth of grass.

(d) a chemical dye capable of general introduction to sprays which would temporarily delineate areas covered without loss of scenic quality thus eliminating overlap in coverage.

(e) chemicals with a faster action and longer effectiveness for grass retardation, ground fertilization and soil sterilization.

(f) reduction in the spreading tendencies of applied chemicals into areas where their presence is damaging.

(g) chemicals which are less sensitive in their effectiveness to the season applied.

(h) a chemical or synthetic hormone to break the dormancy and increase the fertility of natural-growth seeds of native pines, low growing woody shrubs, low-bush blueberry, bearberry, sweetfern, checkerberry, woodbine, etc. Our use of said seeds under these circumstances would be a saving over the present placement of such as seedlings for replacing grassed areas.

(i) a chemical to speed the disintegration of stumps in place.

(j) a synthetic mulch with lasting qualities and with a resistance to wood growth, as a substitute for present costly hay or wood chips.

(k) a brush growth retarder which will not brown out for areas where control for sight distance is at a costly premium.

(l) a chemical development which will augment water retention in plants and grass thereby enhancing their resistance to drought.

(m) a chemical for application to wood chips which will reduce weed growth.

(n) the fertilizer could be in the form of a highly potent pellet or capsule, having a life expectancy of two years duration together with the ability to increase rapidly the growth of all planted materials.

These and many other problem areas in roadside management are considered to merit a concentrated effort in chemical research since they offer enough practical marketing potential.

Roadsides should be constructed in the interest of developing arboretums for future generations. If we fail to continue to plant trees, shrubs, and ground coverings, the future generation will never enjoy or view a naturalistic retreat.

Massachusetts is one of the first States to establish and adhere to this progressive approach relative to Highway Landscape Maintenance; in fact, the method has been in existence for the past twelve (12) years and has proven most successful. Our research experience and the cooperation and advice of leading University Professors and Horticulturists concur with our roadside methods and techniques. This program is a sound and solid approach to the problems of roadside maintenance. Simply because Massachusetts has adopted this "Forward Approach", does not insinuate in any way or manner that the forward-look is in error.

In closing, I shall enumerate and summarize my philosophy and beliefs in maintenance in a progressive fashion, by the application of suitable and proper chemicals.

1. It is time to face facts, we must recognize maintenance problems by providing better roadside **management**.
2. Restoring the balance of nature by proper planting and land usage on our highway systems should be of paramount importance and the direct responsibility of highway officials.
3. The planning and developing of mass planting of large roadside areas and interchanges to assist in providing a green belt of natural areas and resources for the tremendous increasing tourist trade. Massachusetts evaluates its tourist industry, each year, in the vicinity of \$4,500,000.
4. Reduction of roadside maintenance costs, through the planting of trees, woody shrubs, vines and various other ground covers, thus eliminating the mowing of grass forever, and providing scenic highways for future generations.

5. Massachusetts is doing its utmost to prevent the creation of a Frankenstein Monster in the form of a costly necessary mowing, after the seeding of grass, which would be a prohibitive maintenance burden for future generations to bear. We want our roadsides to provide scenic enjoyment without being looked upon as an expensive pleasure.

6. The chemical industry, relative to the use of new chemical and spraying methods, must initially institute and increase their participation in the dissemination of informational and educational programs, through all mass media, not only for their customers but for the general public, in particular, this should be the paramount objective of all public relation departments. This is especially needed in the magnitude of the planting programs which are now on the planning boards of the 50 States and, also, for the massive Bureau of Roads Interstate Projects.

JLB/cmr

THE GARDEN CLUB OF NEW JERSEY AND WEED CONTROL

Elizabeth T. Cooke¹

At the invitation of Mr. Alfred H. Fletcher, Director of the Department of Environmental Health of the New Jersey State Department of Health, four members of the Horticulture Council of the Garden Club of New Jersey met in the office of the Dean of the College of Agriculture at Rutgers, The State University, in June of 1963, to discuss ways in which the federated garden clubs of New Jersey might participate with the State Department of Health and the Extension Division of Rutgers University in their goal of the ultimate control of pernicious weeds in New Jersey, especially poison ivy and ragweed.

Present at the meeting, in addition to Dean Merrill and Mr. Fletcher were Mr. John Zemlansky, expert of the State Department of Health as well as Secretary of this Conference; Mr. John M. Curran, also of the State Health Department; and Dr. Donald A. Shallock, Extension Specialist in Weed Control at the College of Agriculture at Rutgers. The four members of the Horticulture Council were Mrs. F. Morse Archer, Jr., Conservation Chairman of the Garden Club of New Jersey; Mrs. Paul Clawson, Chairman of Junior Gardeners, Garden Club of New Jersey; Mrs. Robert R. Green, past Horticulture Chairman; and Mrs. Thomas T. Cooke, Chairman of the Horticulture Council.

At this conference the decision was made to devote part of the first Horticulture Workshop of the Garden Club of New Jersey, which was planned to be held at the Log Cabin, Rutgers, on September 11th, to the subject of "Banishing Unwanted Weeds," and Dr. Shallock consented to be the speaker.

Realizing that August is the month when the common ragweed (*Ambrosia artemisifolia*) and giant ragweed (*Ambrosia trifida*) begin to pollinate, the Chairman of the Horticulture Council, early in August, sent a letter to eleven important newspapers which have statewide coverage in New Jersey, which urged their readers to pull ragweed, and to write to the Agricultural Experiment Station at Rutgers University at New Brunswick for their excellent descriptive and informative pamphlet "Ragweed and Its Control." A flier, "The Time is Now" on the same subject, was mailed to the Presidents of our 168 garden clubs with their invitation to the First Horticulture Workshop asking our members to encourage the pulling of ragweed in their own neighborhoods.

Mr. Fletcher helped to arouse interest by writing an "Important Message Concerning Poisonous Plants" for our September-October number of "Newsleaf" the Garden Club of New Jersey publication, which has a circulation of 8,000.

At our Workshop, Dr. Shallock's illuminating and interesting talk was received

1. Chairman, Horticulture Council, Garden Club of New Jersey

with enthusiasm. Dr. Shallock brought some live specimens of *Ambrosia trifida*, and Mr. Fletcher sent a large three-panel exhibit on ragweed. Literature on how best to destroy ragweed and poison ivy, supplied by the Extension Service of Rutgers University was distributed to interested members representing twenty clubs. As Dr. Shallock explained in his splendid talk, ragweed continues to pollinate and seed well into the autumn so that even late extermination is rewarding.

We realized after Dr. Shallock's talk that while ragweed is so ubiquitous, so wide-spread, that it would seem almost hopeless for the average layman to attempt to combat it, even one ragweed plant can pollute the air with billions of pollen granules during its season of pollination. As soon as the flowers ripen, pollen granules become airborne. The destruction of even one plant is worth while. An acre of ragweed will produce as much as 60 pounds of pollen every year, and one full-grown ragweed plant may produce several million pollen grains in one day.

The Garden Club of New Jersey, with its 8,000 members in 168 clubs dotted all over the State, would seem to be in a favorable position to initiate a state-wide campaign to eliminate ragweed and poison ivy in our Garden State. Of course, we could not do this alone - but with the aid and cooperation so generously offered by the State Department of Health and Rutgers University we will be in a position to spread accurate information to our membership and through our members to citizens young and old all over our State. Our task will be lightened by the fact that over 100 municipalities in New Jersey have passed ordinances making the abolishing of poisonous weeds mandatory.

Five Year Plan

As ragweed seeds are long-lived and may persist for a number of years, sending up a fresh crop of seedlings long after the parent plant has been eliminated, a Five Year Plan would seem to be indicated.

This Five Year Plan would involve a coordinated program in which many of the Committees of the Garden Club of New Jersey would work with the individual member clubs: The Committees on Civic Improvements; Conservation; Garden Centers; Junior and High School Gardeners; Horticulture Council; Publicity, and Roadside Beautification.

As the most serious air pollution - as affecting health and comfort - will occur in and around inhabited areas where earth has been newly bared for developments, along roadsides and in vacant lots and waste places, it is here that a serious attempt must be made to abolish it and to prevent further spread.

The Horticulture Chairman, either individually or through an appointed sub-chairman should survey the neighborhood or territory covered by her Club for ragweed and poison ivy, in cooperation with the Committees on Civic Improvement and Roadside Beautification. These committees in turn could:

- a. Contact their municipalities to ascertain whether they have anti-poisonous weed ordinances; offer their help in spotting and identifying infestations of ragweed and poison ivy, or
- b. If there is no municipal ordinance in their territory, suggest that one be passed and offer cooperation for a survey.
- c. An identification campaign illustrating Common Ragweed (*Ambrosia artemisifolia*), Giant Ragweed, (*Ambrosia trifida*), and Poison Ivy, (*Rhus toxicodendron*), Poison Oak (*Rhus diversiloba*), and Poison Sumach (*Rhus venenata*).

Identification of poison ivy (*Rhus toxicodendron*), in New Jersey the most common of the poisonous *Rhus* family, is of the utmost importance. The other two poisonous plants, though on the danger list as far as health is concerned, are fortunately not as widespread or as easy of access as is poison ivy.

This identification campaign could consist of posters and pamphlets placed in banks, club houses, libraries, garden centers and department stores. Potted specimens of ragweed plants make effective exhibits, and as they require heavy watering to keep alive would help to illustrate how weeds rob the soil of moisture.

- d. Publicity, starting early in the spring when ragweed first appears, and stepping up in June and July before the pollination period, could describe adverse effects of ragweed pollen on health and cite numbers of cases of poison ivy victims of previous years; stress methods of prevention by elimination of the plant rather than remedial care of victims.
- e. Jobs for our junior and high school gardeners as spotters and helpers - especially in the case of ragweed.
- f. As the poison ivy menace cannot be combatted by cutting or pulling, a spray program would seem of prime necessity, and would best be undertaken on a large scale by municipalities. However, as 2-4-D is nontoxic to humans and easy to use as a spray it can be recommended to our members for spot control and use on a small scale where municipal aid is not obtainable. Assist in pulling ragweed from small patches where a spray program would be unwieldy and cumbersome and timetaking for municipal trucks.

We feel that if this program is faithfully followed it might go a long way towards eliminating ragweed and poison ivy - these twin vegetative menaces to health and comfort. If our efforts are successful in New Jersey, we hope other State garden clubs will be inspired to follow our example, especially in this Northeastern Area, where the need is greatest.

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KILL WEEDS AND COMPLAINTS BY A POSITIVE ACTION PROGRAM

Kenneth M. Jones¹

The Bloomfield noxious weed control program is designed to remove ragweed and poison ivy from the municipality and thereby alleviate suffering and minimize citizen complaints from hay fever sufferers and those susceptible to contact with poison ivy.

Bloomfield is a suburban community of about 52,000 population, within the heart of the Greater New York metropolitan area. It has the fourth largest population in Essex County, New Jersey; the States largest County, with a total of almost one million persons.

This is the story of Bloomfield's efforts to develop an efficient, effective and economical weed control program.

Bloomfield covers an area of 5.4 square miles and has 98.9 miles of streets. There are two county parks within the town, there are portions of two country clubs, and there are six parks and playgrounds under supervision of the Recreation Commission. During the summer, the Recreation Commission additionally operates supervised programs at eight of the public school playgrounds.

Our problem has been to establish the most effective noxious weed control program to fit the community need.

There are three generally accepted methods for noxious weed control: one is to place the responsibility of abatement of the nuisance upon the property owner; the second is the utilization of an independent contractor, and the third is for the official agency to perform the work. There is no "best" method.

Flexibility is of greatest importance in ultimately finding the most suitable program for the specific problem. Bloomfield has utilized all three techniques.

Noxious weed control within Bloomfield, until nine years ago, initially consisted of written notification to the property owner to abate the nuisance after specific complaints to the Board of Health and also some cutting upon public property by the Public Works Department. This control proved unsatisfactory upon private property, because of the problem of absentee owners and because of the time lapse between notification to abate the nuisance; re-inspection and the appearance of the negligent offender in court. Many unproductive manhours were spent in inspections, re-inspections and court appearances.

Beginning in the summer of 1954, an independent contractor was engaged to spray ragweed and poison ivy on both public and private property. This was a tremendous improvement. Under this method, a Board of Health sanitarian surveyed

¹ Health Officer, Bloomfield Health Department, Bloomfield, N. J.

the entire town, by riding the municipality street by street and "spot marking" a municipal map, locating the ragweed and poison ivy. It is important to use a map of sufficiently large scale to make pin-pointing of locations easy. Several authorities suggest a scale of approximately 1 inch equals 600 feet.² Separate colors were used upon the map to differentiate between ragweed and poison ivy.

The sanitarian accompanied the independent contractor to point out areas requiring spraying and to keep the time, because the contract was written upon an hourly rate of pay plus cost of materials. The work quality of the independent contractor was excellent. He was, however, an "independent contractor"; the degree of work was dictated by the volume of the contracts assumed and the variables of weather. It was never known when the work would be completed. Because of the contractor's high hourly rate, the tendency was to by-pass small areas and treat only the larger patches of noxious weeds.

In early 1957, one of our sanitarians suggested, that an Indian Pump of five gallon capacity with an appropriate mix of 2,4-D be carried in the car while making the survey. Then all curb-side and small areas of ragweed could be sprayed immediately at survey time. This technique worked remarkably well; our staff treated the small patches consisting of anything from one plant to an area less than about 100 square feet. All larger stands of ragweed and poison ivy were treated by the private contractor in 1957.

In the early spring of 1958, the Public Works Department purchased a jeep with four wheel drive, painted it bright yellow and installed a red flasher on the cab roof. This inaugurated our adoption of the third method of weed control. The Health Officer arranged with the Town Engineer for the use of the jeep in late June and early July. Inter-departmental cooperation within our municipality is of the highest order. The Engineering Department makes available their jeep and the Police Department furnishes safety protection with one of their cars with a flashing roof light behind our spray vehicle on high speed roads. A frame of 4 x 4's was constructed to fit snugly in the jeep body behind the cab, thereby preventing any side play or shifting of the tank mounted in the rear. The following materials were purchased: a 42 gallon pneumatic tank with a working pressure of 100 pounds, a pressure relief valve set at 95 pounds, a pressure gauge, fittings, 150 feet of plastic-nylon reinforced hose and an adjustable trigger nozzle. This equipment cost approximately \$70. The fill port on the top of the tank is fitted with a one inch spring action gate valve. The fill cap is increased to two inches to hold a complete charge of chemical.

The side port is equipped with a 3/4" check valve and a 3/4" spring action gate valve. This assembly is placed thusly to prevent any possibility of the weedicide from entering the potable water system.

The pressure gauge located on the top of the tank also has incorporated in the assembly a spring type air valve so that air pressure may be added from any

² "Ragweed Pollen, Sampling and Control." A. H. Fletcher, Director, Bureau of Environmental Health, N.J.S.H.D. and C.J. Velz, Chairman and Professor, Department of Public Health Statistics, U. of Mich., School of Public Health; page 8

pneumatic air supply available at all gas stations. The hose connection for spraying is taken off the bottom port of the tank which has a manual control gate valve. The fill line at the end of the tank is attached to a city water hydrant cap with a check valve also at the hydrant end of the line. The tank may be filled with water from the hydrant and thereby develop a 90 pound pressure within the tank.

Where necessary, a small gas powered compressor could be mounted on the unit. A universal hydrant wrench makes water available at the nearest hydrant. Arrangements are made in advance with the water authority for use of the street hydrants. With this equipment, it is possible to treat all ragweed and poison ivy within the town.

Playgrounds and parks are the first priority, then the large areas such as a power line transmission right of way and a water transmission line right of way and the remaining undeveloped areas of the old Morris Canal right of way. This is followed by a street by street treatment until the community has been covered.

Where a property owner objects to the service upon private property, they are served with notice to conduct their own abatement procedures and the case followed to assure compliance. I might add there has been but two such situations in the past six or eight years.

Originally ragweed and poison ivy were treated separately. It has been found that in our situation, it is more economical to combine 2,4-D and 2,4,5-T in each tank³ rather than to make the return trip to treat poison ivy. Large growths of poison ivy receive separate attention.

The weedicide is measured, combined and bottled in odd hours just before the program is about to begin. This minimizes handling in the field.

More than 3,050 gallons of weedicide was dispensed during the 1963 season. Based upon the use of 250 gallons per acre⁴ it is estimated that between twelve and thirteen acres were treated. It is impossible to offer better than a rough estimate of the area treated because approximately 80 percent of the work was done on relatively small marginal areas.

A bonus in any weed spraying program is also the opportunity to destroy, at the same time, any stands of marijuana or common hemp, which may exist. Marijuana grows profusely throughout our state and can readily be harvested by those persons interested in manufacture of the "reefer" cigarettes.

Personnel should be furnished with coveralls, gloves, masks, goggles and heavy work shoes as a protection against contact dermatitis, inhalation of spray and protection from briars, trash and broken glass.

3 "Poison Ivy and Its Control" D.E. Wolf and G.H. Ahlgron, N.J. Agr. Experiment Station, Circular 532, page 2

4 Ibid. page 10

The personnel in the field who activate a spraying program are the key to the success of the program. That is the reason staff personnel are utilized in Bloomfield. Anything less than a complete spraying and destruction job will invoke citizen complaints and criticism. Carelessness by a "hose happy" employee can do tremendous damage to ornamental shrubs and gardens, often followed by attendant litigation. It is tremendously important for personnel to have an acute awareness of the potential damage that can occur from careless spraying or carrying minute particles of the spray by wind drift. You may recall the recital in "Silent Spring" of the disfiguring brown areas created by thoughtless use of weedicides.⁵

Any spraying within four hours of a rainfall will wash off the weedicide and the area must be resprayed. A "weather eye" for wind direction and velocity and possible rain showers are a necessity for intelligent spraying.

A municipality should have legal authority, either by municipal or Board of Health ordinance, to permit noxious weed control upon private property. It is suggested that the ordinance include: (a) requirement that property owners remove hazardous weeds from their property, (b) authority to declare such growths a public nuisance, (c) empower the municipality to remove or abate the nuisance through its Board or Department of Health.⁶

In 1963, Board of Health personnel costs amounted to \$450.16. The charge for the use of the jeep was \$72. and 13 gallons of 2,4-D and 2,4,5-T amounted to \$74.79, making the total cost \$625.60.

Citizen complaints about ragweed and poison ivy dropped to less than ten complaints during the summer of 1963. This is in sharp contrast to former years when complaints by phone and in writing averaged 125 to 150 a season. For comparison, the year 1962 saw 1,876 gallons dispensed at a total cost of \$370.65 and in the year 1961 there was 2,492 gallons dispensed at a total cost of \$443.47.

The possibility of referring the cost of abatement to the tax department as charge against the real estate has been considered. After a cost study was made it was found inadvisable to implement such a program. In no instance would the sum recovered merit the time and paper work involved.

Any municipality inaugurating a noxious weed control program will find enthusiastic endorsement from its citizens, especially those susceptible to "hay fever." Do not, however, "hide your light under a bushel"; it is an excellent opportunity for health education and good public relations. Use news releases, your local radio stations, exhibits, demonstrations, identifying signs on your work vehicles and any other means of publicizing the program.

Difficulties appear and require solution in the development of any new program. They must be solved one by one as the problems arise. The greatest reward comes when the results are surveyed at the completion of the program and it can truthfully be said "Well Done."

⁵ "Silent Spring" Rachel Carson, Houghton Mifflin Co., page 70

⁶ "Procedures of Promoting and Operating a Ragweed Control Program," A. H. Fletcher, Public Health News, Vol. 36, No. 5, May, 1955.

PLANT LIFE AS AIR POLLUTION INDICATORS

Ida A. Leone, E. Brenman, and Robert H. Daines¹

This past fall during the latter half of October, the Metropolitan area experienced one of its worst air pollution episodes in more than a decade. Few people in the area were unaware of the situation, judging from the newspaper headlines, and the eye-tearing observable on the streets of Manhattan on most days during the period. At this time, the atmospheric level of oxidants, the pollutants responsible for smog and eye-smarting effects, approached concentrations found in the Los Angeles atmosphere for which that community has become notorious. According to research done in Los Angeles it requires 0.15 ppm oxidant in the atmosphere for human beings to experience discomfort, a level which was exceeded on many days during the October smog period. However, the plant world, had it been consulted, would have given a forewarning at least a week in advance of the situation that oxidant concentrations were approaching a toxic level (0.05 ppm for plants). In fact this period gave an unusual opportunity for plants to display their particular talents for indicating the presence of very low concentrations of pollutants in the atmosphere. And when we speak of the plant world, let us not forget the lowly weed whose fate it is today to be soundly castigated for its less desirable traits.

Agricultural people are concerned with two broad groups of pollutants, the primary or single source emissions which are the result of a particular industrial or fuel-utilizing process, and the products of photochemical reactions which are the result of a whole complex of combustive activities in urban areas.

The primary phytotoxic contaminants include hydrogen fluoride, chlorine, sulfur dioxide, ammonia, hydrogen sulfide, ethylene and perhaps illuminating gas. The remarkable thing about these phytotoxicants is that each one severely affects a particular group of plants which is more or less tolerant to the other pollutants. For that reason plant indicators are very useful in diagnosing the specific gas or gases responsible for an air pollution episode, if observed during their optimum growth period.

Single Source EmissionsSO₂ Injury to Plants

Of these gases, sulfur dioxide, or SO₂, is probably the earliest known offender having been recognized as a phytotoxic agent for more than 75 years. SO₂ is given off from volcanoes, silage treatment on farms, fuel burning (which includes home heating plants, industrial furnaces, incinerators, power plants, and gasoline engines) as well as from chemical plants, refineries, bleacheries, steel mills, and sulfide smelters.

SO₂ is responsible for 2 different types of plant injury. In chronic or chlorotic injury the tissues are not killed, but gradually lose their green coloring as if the chlorophyll producing mechanism has been damaged. Katz and others have actually demonstrated the degradation of chlorophyll in plants exposed to SO₂ gas (4). Acute injury is characterized by clearly marked marginal or, more often, intercostal necrosis. In the damaged areas the tissue collapses and dries out to an ivory or buff color. When SO₂ enters the leaf, presumably through the stomata, it combines with water to form sulfite which is toxic to vegetation. However, as the sulfite is produced it is normally oxidized to the non-toxic sulfate form. Therefore, if the SO₂ is absorbed at a slow rate it is probably all converted to sulfate causing little or no injury. However, if it is absorbed at a rapid rate, the conversion to sulfate is retarded and a build-up of the toxic sulfite occurs.

As is the case with the other phytotoxic pollutants, plants vary in their susceptibility to the SO₂ gas according to species, and even according to variety within a species. Table 1 illustrates the relative susceptibility of a group of common economic crops to SO₂. (4)

Table 1. Relative Susceptibility of Crops to SO₂ in the Atmosphere.

<u>Sensitive</u>	<u>Intermediate</u>	<u>Resistant</u>
Alfalfa	Rhubarb	Asparagus
Tulip	Carrot	Chrysanthemum
Crab apple	Bean	Elm
Begonia	Rose	Lilac
Dahlia	Snapdragon	Dogwood
Raspberry	Elder	Gladiolus
Violet	Wheat	Corn
Columbine	Oats	Cabbage

HF Damage to Plants

Hydrogen fluoride, or HF, is a more recent contributor to the ills of the plant world, having been first recognized as a phytotoxic agent during World War II. Fluoride causes injury to sensitive species at a fraction of a part per billion. The principal sources of fluoride pollution are the rock phosphate and fluorspar industries. There are more than 30 additional industrial processes utilizing or emitting fluorides, including the manufacturing of brick, glass, ceramics, refrigerants, insecticides, and high octane gasolines.

Plant damage from fluoride has a 2-fold importance. Aside from actual damage to the crop itself, there is potential danger to animals or even to human beings feeding on plants high in fluoride content. Typical fluoride injury to plants has been extensively described in the literature. It consists of tip and marginal necrosis to the youngest fully expanded leaves. Whereas, SO₂ enters a leaf through the stomata, fluoride is believed to be absorbed throughout the leaf surface as well

as through stomata. Fluoride is retained in the leaf to a much greater extent than is SO_2 , therefore chemical analysis is of great value in diagnosing injury due to fluoride gases. Table 2 shows the relative susceptibility of common crops to atmospheric fluorides (2).

Table 2. Relative Susceptibility of Crops to HF in the Atmosphere.

<u>Sensitive</u>	<u>Intermediate</u>	<u>Resistant</u>
Chinese apricot	Peach	Pepper
Gladiolus	Tomato	Spinach
Day lily	Bean	Tobacco
Corn	Zinnia	Petunia
Ponderosa pine		Willow
		Privet

The remaining single source pollutants are of lesser importance but there have been reports of injury to 30 species of plants from chlorine escaping from a swimming pool, to tomato, sunflower and coleus from ammonia fumes and to cultivated orchids from ethylene in the greenhouse (6).

Products of Photochemical Reactions

Ozone Injury to Plants

The second large group of phytotoxic pollutants is made up of the products of photochemical reactions. These products are formed by the action of ultra-violet rays on mixtures of unburned hydrocarbons, particularly from automobile exhaust, and nitrogen dioxide in the atmosphere. Without delving too deeply into the mechanics of these complex reactions we may simply state that they produce two significant phytotoxic pollutants, ozone and oxidized hydrocarbons. While there is no chemical analysis known which can distinguish between these two types of pollutants, plants show a remarkable ability to do so. Ozone injury is distinguished by the fact that it invariably affects the upper leaf surface of sensitive plants, causing a collapse of the palisade cells or the elongated cells immediately under the upper epidermis. Where there is no palisade layer, as in cereals, the injury is observable on both leaf surfaces. Crops which are particularly sensitive to ozone are listed in Table 3 (3).

Table 3. Crops Sensitive to Products of Photochemical Reactions.

<u>Crops Sensitive to Ozone</u>	<u>Crops Sensitive to Oxidized Hydrocarbon</u>
Tobacco	Endive
Spinach	Chicory
White potato	Cultivated Dandelion
Cucumber	Swiss chard
Alfalfa	Petunia

Oxidant Injury to Plants

The second group of photochemical reaction products includes oxidants i.e. oxidized hydrocarbons of which peroxyacetyl nitrate, commonly known as PAN, is the chief offender. In contrast to ozone, PAN attacks the lower surface of the leaves of sensitive plants causing a silvery sheen which has been called "silver leaf". Crops sensitive to PAN include many of the salad greens such as Swiss chard, cultivated dandelion, beet, chicory and endive as well as tomato and petunia. (Table 3)

Weeds as Indicators of Air Pollution

So far we have omitted mention of weeds in the discussion of air pollution indicators, preferring to deal with them separately for this audience. If plants in general are of inestimable aid in detecting the presence of minute quantities of gaseous pollutants in the atmosphere, weeds are ideally suited for this role. Certain weeds are common in virtually all of the agricultural areas of the United States. Therefore, by studying the effects of various pollutants on a relatively small number of species, air pollution damage can be assessed in any part of the country. The complaint that, because of their hardy nature, weeds might be less sensitive to air pollutants than economic crops has little validity. Many investigators, including ourselves have seen instances during experimental fumigations where weeds have been more sensitive to certain gases than some of the commercial crops. Several of these investigators have directed their attention to specific studies on the effects of air pollutants on weeds. Benedict and Breen (1) selected 10 representative species out of a list of weeds submitted to 25 agricultural experiment stations throughout the country for frequency of occurrence, and exposed them to increasing concentrations of 6 common pollutants. Results of weed susceptibility to the 3 pollutants discussed are presented in Table 4.

Table 4. Decreasing Order of Susceptibility of Ten Common U. S. Weeds to Three Atmospheric Pollutants.

<u>SO₂</u>	<u>HF</u>	<u>Oxides of Nitrogen</u>
*Chickweed	*Nettle-leaf goosefoot	*Mustard
*Mustard	*Chickweed	*Sunflower
*Annual bluegrass	*Pigweed	*Annual bluegrass
Sunflower	Annual bluegrass	Dandelion
Kentucky bluegrass	Lamb's-quarters	Cheeseweed
Pigweed (Amaranthus retroflerus)	Mustard	Kentucky bluegrass
Cheeseweed	Kentucky bluegrass	Chickweed
Lamb's-quarters	Cheeseweed	Nettle-leaf goosefoot
Dandelion	Sunflower	Lamb's-quarters
Nettle-leaf goosefoot	Dandelion	Pigweed

* Significantly more sensitive than others in list.

Middleton and his associates (5) of Riverside, California, list 8 weeds useful in their area for recognizing plant-damaging air pollutants of the smog-producing type in that area (Table 5).

Table 5. Weeds as Indicators of Level of Oxidized Hydrocarbons.

<u>Low Level</u>	<u>Moderate Level</u>	<u>High Level</u>
Annual bluegrass	Annual bluegrass	Malva
	Lambs-quarters	Sonchus
	Chickweed	Wild oat
	Nettle	Annual bluegrass
	Rocket	Lambs-quarters
		Chickweed
		Nettle
		Rocket

Similar experiments were conducted at the New Jersey Agricultural Experiment Station. In one experiment, eight weeds common throughout New Jersey were exposed to increasing concentrations of hydrogen fluoride in a fumigation chamber.

Table 6. Percentage of Foliage Injured at Increasing Fluoride Exposures.

<u>Weed Species</u>	<u>Fluoride Exposure</u>			
	<u>0.09 ppm per 3 hrs.</u>	<u>0.29 ppm per 3 hrs.</u>	<u>0.51 ppm per 3 hrs.</u>	<u>1.09 ppm per 1½ hrs.</u>
Smartweed	10	80	75	100
Sorrel	5	50	90	100
Crabgrass	-	10	100	100
Red root	0	10	0	90
Lamb's-quarters	0	0	0	100
Broad-leaved plantain	0	0	0	0
Narrow-leaved plantain	0	0	0	0
Ragweed	0	0	0	0

Table 6 indicates the relative degree of injury to each species at progressively increasing fluoride concentrations. Smartweed and sorrel were found to be most sensitive to fluoride and these species have since been used as indicators in cases dealing with fluoride pollution. Broad-leaved plantain, narrow-leaved plantain, and the obnoxious ragweed all escaped injury even at the highest fluoride levels which were much greater than concentrations found in the atmosphere even of fluoride contaminated areas.

This property of ragweed, of withstanding large quantities of fluoride without exhibiting visible injury, makes it useful for another purpose, that of surveying community air pollution problems. Fig. 1 is an example of such a survey. Samples of ragweed were gathered radially from a suspected center of fluoride pollution and analyzed for total fluoride content. The fluoride content of ragweed near the suspected fluoride source showed the highest fluoride content with a subsequent decrease in content with increase in distance from the source, thereby pinpointing the responsible industry.

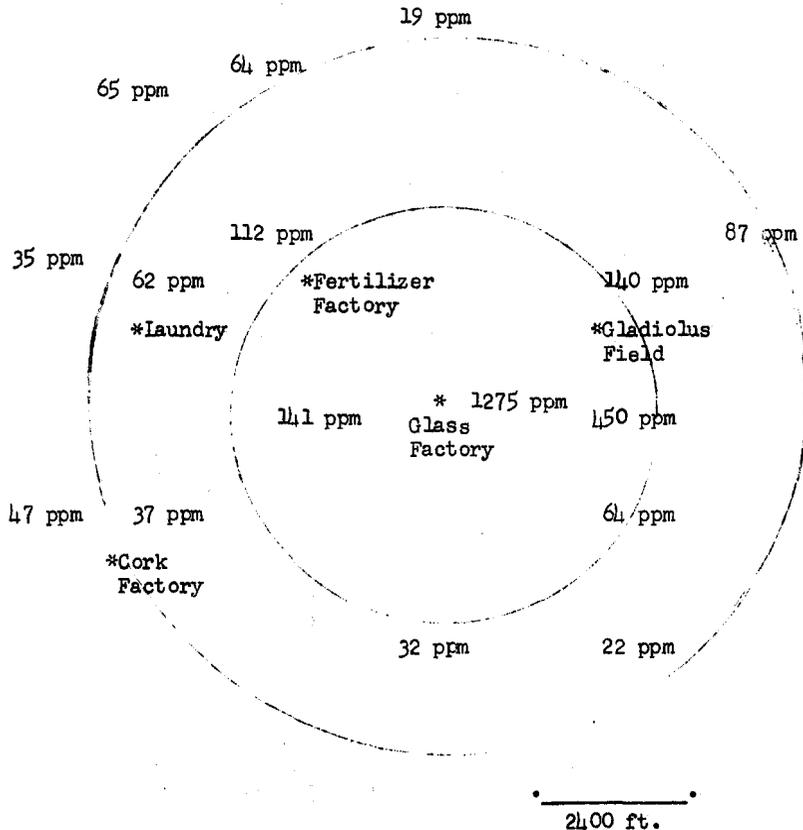


Fig. 1. Fluoride Content (ppm F) of Ragweed Within a Community.

This sort of survey has been made successfully with other weed species as well as with economic plants.

Thus, in the time allotted, we have attempted to demonstrate how vegetation, with particular emphasis on weeds, may be used to identify the presence and even the approximate level of phytotoxic pollutants in the atmosphere. We have mentioned relatively few of the many species cited in the literature. However, knowledge of even these few can be extremely helpful to the plant scientist, farmer, greenhouse operator, and so on. In the case of air pollution, the use of weeds as bio-indicators has been demonstrated in the case of air

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New York State Looks at the Use of Pesticides

by

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A more appropriate title for this paper might be--"New York State Takes a New Look at the Pesticide Situation." New York State, a pioneer in so many areas of public interest, has been intimately concerned with the use and control of pesticides for over 50 years.

For example, my own agency, the Conservation Department, has used pesticides for control work in state forests since the early days of the century. The Department of Agriculture and Markets has supervised the sale of pesticides since 1898. We would like to point out that we use the term "pesticides" in the broad sense and it includes insecticides, fungicides, rodenticides, herbicides, plant regulators, defoliants and desiccants.

Because New York State is a leader, it has done what all good leaders do: it takes a fresh look from time to time at its various functions and responsibilities. During the winter of 1960-61, Conservation Commissioner H. G. Wilm had several informal talks with the heads of other departments involved in the use and control of pesticides. These talks strongly pointed up the growing importance of pesticides and the problems associated with this growth.

Further discussions with Governor Rockefeller's staff led to the establishment of an Interdepartmental Committee on Pesticides in May, 1961. With what we hope is pardonable pride, we would like to point out that this step was taken two years before the publication of "Silent Spring" and two years before the report on pesticides by The President's Science Advisory Committee.

In the beginning, membership on the New York State Interdepartmental Committee consisted of the following departments: Agriculture and Markets, Commerce, Conservation, Education and Health.

Before the Interdepartmental Committee could determine its role in the pesticide picture, it was necessary for each department representative to find out what the other departments were doing in the pesticide field.

Here's a brief run-down of the responsibilities of the departments:

The Department of Agriculture and Markets has jurisdiction over the registration, transportation, distribution and sale of pesticides within state borders. Registration is required each year and about 3,000 pesticide products are registered annually. The Department's laboratories regularly

test agricultural products, both raw and processed. If tests disclose harmful effects--or use is questionable--registration may be withheld.

The Department of Commerce is concerned with the safety of operation in the aerial application of pesticides. Both the health of the pilot and the safety of people where low-flying flights take place are major concerns.

In promoting New York State's vacation lands, the Commerce Department encourages the control of pests in resort areas. The Commerce Department also keeps a close watch over laws affecting manufacturers, distributors and applicators to make sure these business people are not placed in an unfavorable competitive position with their out-of-state counterparts.

The Conservation Department is interested in the protection of natural resources against damage from pesticides. Recently a Pesticide Research Unit was established to evaluate the effects of pesticides on fish and wildlife. A study of the effect of DDT on lake trout in selected New York State lakes has demonstrated that concentrations of DDT have reached a point in certain lake trout waters as to adversely affect trout reproduction. As a consequence, Commissioner Wilm has taken action: the use of DDT in forest pest control programs and for the control of black flies and mosquitos at state campsites in watersheds inhabited by lake trout has been discontinued.

The Conservation Department is also a user of pesticides in such work as forest pest control, already mentioned.

A program of special interest to this group is a Water Chestnut Control Program. An air boat using 2,4 D amine has been successful in clearing a water chestnut infestation in the Schenectady area of the Mohawk River so that fishing, boating and other water sports have been resumed.

The Education Department is the research arm of the Interdepartmental Committee. The control of pests is not in itself a function of the Education Department; it emphasizes more the development of methods and techniques which can be utilized by other state departments. Experiments with biological control agents as well as chemicals are included in its studies.

The Health Department is concerned with the effects of pesticides on humans through environmental influences in air, water, milk, food, housing and related matters.

The effect of pesticides on water supplies is a primary interest. With the cooperation of Syracuse University, the Health Department sponsored a pilot study to determine the effects of certain chemicals, including pesticides, on water supplies. This study has led to an expanded project to assess effects on an entire watershed.

This brief run-down, of course, is just a capsule summary of the responsibilities of each department in the pesticide field. This knowledge provided a helpful springboard for the next step. With a better understanding

of the work of member departments, the Interdepartmental Committee was able to visualize more clearly its role in the state pesticide picture. Four objectives were established:

1. Coordinate the activities and programs of member departments dealing with pesticides;
2. Establish a central referral point to handle inquiries from the public;
3. Encourage research studies;
4. Develop ways of keeping the public informed on New York State pesticide activities.

Let's take a look at some of the things the Committee has done to achieve these objectives.

In regard to its objective of coordinating activities, the Committee meeting provides an open forum for discussion. There are cases where certain departments have reshaped or modified programs to keep in line with other departments' policies. In general, the Interdepartmental Committee has created a climate which has resulted in a more unified approach to pesticide programs.

The objective of establishing a central referral point to handle public inquiries should strike a responsive chord in you who have the time-consuming job of handling this type of correspondence. Incidentally, in New York State, we have some especially active and talented letter writers. The Committee has developed a practical method of handling inquiries: letters are subjected to a round-robin review and a reply drafted representing the viewpoint of all departments concerned. This procedure has helped to foster a better integrated approach to pesticide problems than in the pre-committee days when each department acted unilaterally.

The third objective of the Committee is the encouragement of research. In spite of the good work in progress, the need for more facts is recognized and stepped-up research efforts have been recommended. As a result, the line was held on most funds in a very tight budget year and in a few cases there has been some expansion of pesticide studies.

In regard to the objective of keeping New York State citizens informed of pesticide activities, the Interdepartmental Committee prepared a leaflet, "The Use and Control of Pesticides in New York State." This leaflet has been given wide distribution and served to inform the public of the constructive work being done by New York State in the field.

These, then, are the Committee's objectives and its accomplishments so far.

Although the Interdepartmental Committee is solely advisory, it is generally agreed that the objectives of the Committee have been fulfilled remarkably well for such an informally organized group.

One factor limiting the work of the Committee is the fact that each Committee member already has a full-time job with his own department. As a result, Committee work has to be sandwiched in between the demanding duties of his regular job. Thus, you can understand how greatly pleased the Committee was when it was invited to affiliate with the State Interdepartmental Health and Hospital Council.

The Council was established by Executive Order. Therefore, it gives the Interdepartmental Committee on Pesticides official status. It also gives the Committee the services of an Executive Secretary, which greatly expedites the business chores of the Committee. When the Committee became associated with the Council, its membership was enlarged by the addition of the Department of Public Works and the Department of Labor.

We are sure this group is familiar with the roadside weed control programs of the State Department of Public Works. The Department of Labor keeps a close watch over the plants of the manufacturers of pesticides to insure safe working conditions.

The Interdepartmental Committee recognizes that there are many problems still to be worked out. One question continually arises: Can existing New York State laws regulating pesticides be improved?

For over a year, the Committee has studied pesticide legislation in the Federal and other State governments throughout the United States. The Joint Legislative Committee on Natural Resources has also become interested in the legislative aspects of pesticide regulation. Its chairman, Assemblyman Pomeroy, recently established a sub-committee to study the matter. The Interdepartmental Committee is cooperating with this sub-committee.

The Interdepartmental Committee does its best to maintain an objective viewpoint. It is aware of the benefits derived from pesticides and the dangers associated with indiscriminate use. It operates on the principle that a safe balance can be struck between the two.

The Interdepartmental Committee on Pesticides believes the fresh look that it has taken will result in sound recommendations that will be helpful to both the Executive and Legislative branches of the government.

The Committee also hopes it will assure New York State citizens that thoughtful consideration and constructive action is taking place at all levels in the State government.

THE EFFECT OF DIVERSE WEED CONTROL PROGRAMS ON PUBLIC HEALTH

Donald A. Schallock^{1/}

The control of weeds injurious to the health and welfare of the public is required in many municipalities, townships, and counties. Authorized under a public health law of the state government, these local governing bodies may enact and enforce ordinances requiring the control and removal of these weeds, principally giant and common ragweed and poison ivy. Marijuana removal is also required under restriction by the Bureau of Narcotics.

Participation of local governments in a program of weed control is spotty and spasmodic. Lack of trained personnel, lack of funds, and lack of concern are the reasons stated for the absence of the program. Improvement in local participation is expected due to the efforts of the State Department of Health, a greater public awareness of the problem, and increased outdoor recreation created by more leisure time.

There are other weed control programs, some allied with the public health effort, that influence the public health aspects of weed control.

Seed Laws

All states have weed control provisions written into a seed law. This law, operating under a state seed control official, prohibits the movement and sale of crop and vegetable seeds containing weed seeds classed as prohibited or restricted. Where ragweed may not be classified as prohibited or restricted, the weed control methods and seed cleaning procedures employed are very likely to remove ragweed seeds as well as those for which the state seed law is intended.

Weed Laws

Many states, particularly in the central and western states, have a state weed law. This law is executed under a state weed commission operating within the State Department of Agriculture. The state commissioner works through county and township weed commissioners who apply the law to local weed problems. Weeds classed as potentially dangerous to agriculture are removed before they go to seed.

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Northeastern states, including New Jersey, are presently investigating the state weed laws with the idea of falling in line with the other states in having a uniform state-by-state control of weeds. This movement, under consideration by the secretaries of agriculture, now is sure to have far-reaching effect on the weeds affecting public health directly by allergies, infections, or oral poisons.

Highways

The highway weed control is the best working example of two programs united for a common goal. The first vegetation that volunteers on the raw cut of a highway is ragweed. The first step in that highway program is to grass the shoulder and slopes. This eliminates most of the ragweed since it will not compete with a mowed sod. Ragweed still persists, however, in the compacted soil fringe between the paving and the sod. Ragweed also persists along guard rails, bridge abutments, sign posts, and areas inaccessible to the mower. Poison ivy festoons the trees, fences, walls, and slopes out of the mowed area. Chemical weed control is used to control these and other weeds as an economical aid to highway management. The highway department has engineering and safety reasons for controlling weeds while the public health people have the safety and comfort of the public to provide for. Both purposes are attained from one program.

Industries and Public Utilities

The control of weeds by the railroads, public utility rights-of-way, and by industries around their areas and installations are important to public health. The nature of these areas permits invasion of ragweed as well as other unsightly weeds. The primary reason for control may be for fire protection, ventilation, or increasing beauty and utility of the property, but the side effects of controlling ragweed are an important contribution to the over-all program of controlling ragweed wherever it may occur.

Home and Grounds

We may be inclined to under-rate an increasingly important development, that is, weed control around homes and grounds. Recent studies show that pollen released by flowering ragweed plants in close proximity to the sufferer cause a greater antigenetic response to persons suffering from hay fever than ragweed pollens carried several days by air currents over some distance. This means that the control of ragweed around the home and grounds is important. The nurtured and manicured lawns, the hedged borders, and the clipped edges of our lawns, golf courses, parks, cemeteries, and athletic fields buffer the vulnerable public from the more potent pollen as well as to achieve the beauty and utility for which the landscaping was intended.

Cropland

The control of ragweed that occurs as a result of the control of weeds on cropland is of the greatest importance as compared to the other programs. Although ragweed peculiarly follows the highways and other developing areas, it has long infested our crop areas.

Ragweed cannot be tolerated in competition with crops. As compared to corn, pound for pound, a common ragweed takes 3 times more water, 2 times more nitrogen, $1\frac{1}{2}$ times more phosphorus, 3 times more potassium, 6 times more calcium and 2 times more magnesium (1). These data illustrate that ragweed and food crops are not compatible. By hand, hoe, cultivation, and chemical, man is required to eradicate weeds like ragweed for self preservation. The food and fiber we require for our high standard of living and the nutritious foods we eat are possible through these efforts.

Ragweed has been and is being almost completely controlled in our large acreages of farm land in corn, hay and pasture. Smaller acreage crops of vegetables and horticultural specialties are managed so intensively that no ragweed exists there. The problem areas in ragweed have largely been in crops like potatoes and tomatoes. These crops are cultivated early, but as the vines cover the ground, cultivation is no longer possible. Also, as the plants mature, the vegetative tops thin out, permitting weeds to emerge and grow from mid-July to frost. It has been observed by hay-fever sufferers that these fields which can no longer be cultivated, where plants no longer shade the ground, and waste areas not grazed, mowed, or cultivated are the sources of pollen that cause their discomfort.

Recent research in weed control has developed recommendations on most if not all crops that will control all weeds in cropland until frost. As vacant land is used, this source of pollen will also be removed.

Poisonous Weeds

Poisonous plants which are a hazard to livestock are also a threat to humans, particularly children. No year passes but that one or two young children die in New Jersey from eating the berries of deadly nightshade. During October of 1963, two children in New York and one in Camden, New Jersey, came near death due to chewing the root of pokeweed. Many other young children suffer temporary illness from eating or chewing horsenettle, snakeroot, pokeweed berries and jimson weed. Cows having eaten some poisonous weeds may pass the poison through the milk to infants.

(1) Klingman, Glenn C. 1961 Weed Control As A Science. John Wiley and Sons, Inc., New York. pp. 17.

Poisonous weeds are as much a public health concern as the allergy producing plants. Generally, these weeds will be eliminated in the programs already being carried out for the purposes for which each is intended. Some educational effort could be stepped up to inform parents of the poisonous weeds that might be a hazard to their children.

Summary

Diverse weed control programs, each designed to serve the person, group, agency, or industry for which a weed or weeds are a problem, will immediately or ultimately serve public health. An intelligently conceived and judiciously executed weed control program will provide for public safety where a chemical is involved.

It is important to recognize the interrelations of the various weed control programs. If each program will take the other into consideration, more benefits will be achieved. A slight modification in an existing or proposed weed control program may more adequately serve the needs of the public health and welfare.

Observations on the Germination of Common Ragweed

E.G. Anderson¹

This is a report of work conducted quite a few years ago to answer questions concerning the control of common ragweed. Control measures being advocated at that time included the growing of pure stands of cereals to permit after harvest cultivation. There was no question that cultivation after the crop had been removed would control growing weeds, but how effective was this treatment in reducing or controlling common ragweed? There was no clear-cut answer to this question but some believed that the incidence of common ragweed was steadily increasing. My approach to the problem was a study of the germination behaviour.

Although mature seeds were observed to drop from plants during a period ranging from September 26th through November 8th, over a 4-year period, seedlings were not found up to the time of freeze-up. Very few of the seeds were ready to germinate at maturity as indicated by several laboratory tests.

When the seeds were placed on moist blotters in a Jacobson germinator at 20 to 30 degrees C., the average germination after 28 days, over the 4-year period, was 1.4 percent. The use of a 1 percent ceresan dust did not improve the germination, but when tested on moist sand indoors the average germination increased to 2 percent. The germination increased to 3 percent when the seeds were floated on water for the 28-day period.

Observations of seeded plots showed that a few germinate as early as April 15th and that the germination period extends through the summer until October 20th, especially when favourable conditions are created. To facilitate easier counting and answer as many questions as possible, a series of plots were set out in an area which had been under sod for about 30 years, and therefore not likely to contain ragweed. Plots were located on sand and on clay, and included established Kentucky blue grass sod, the top of the two soil types and at depths from $\frac{1}{2}$ inch down to 6 inches deep. Where seeds were planted on the surface of the soil or sod, wooden frames covered with $\frac{1}{4}$ inch mesh galvanized wire were used. The cages were firmly pegged into the soil.

Although the results from similar treatments in each of the two successive years of the project were averaged, there was some indication that a higher germination occurred in sunlight when compared to those which had been planted in partial shade.

The influence of the various treatments on the germination one year later is strikingly shown in Table 1. Where the seeds had been dropped on top of sand sod, the germination was 8.2 percent, but if the seeds were on clay sod the germination was 18.5 percent. Where the sod had been removed the germination was 36.6 percent on top of clay and 48 percent on top of sand. These might possibly be the conditions obtaining in nature.

Table 1. The germination of Ambrosia artemisiifolia L. seeds on top of sod and soil for one to five years.

Treatment	No. of plots	1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	Total
On top of sand sod	4	8.2	1.7	5.7	1.5	.8	17.9
On top of clay sod	2	18.5	21.5	21.5	4.7	4.7	70.9
On top of clay	8	36.6	.4	1.4	.25	.3	38.9
On top of sand	16	48.0	1.1	.2	.34	.3	49.9

Table 2. Percentage germination of Ambrosia artemisiifolia L. seeds, after being planted in clay and sand from $\frac{1}{2}$ to 6 inches deep for one to six years.

Treatment	No. of plots	1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	Total
In clay $\frac{1}{2}$ "	6	61.8	1.2	2.5	0.0	.06	0.0	65.5
In sand $\frac{1}{2}$ "	18	63.0	3.6	1.6	.4	.6	.4	69.6
In clay 1 "	2	57.5	1.0	.5	.2	.2		59.4
In sand 1 "	11	57.8	4.4	1.9	1.7	1.7	.5	68.0
In sand 2 "	4	36.7	3.0	2.8	2.0	0.0	.5	45.0
In sand 3 "	4	3.2	.8	3.7	.5	0.0	0.5	8.7
In sand 4 "	4	1.0	.2	.5	0.0	0.0	0.0	1.7
In sand 5 "	4	0.0	.7	1.0	.5	0.0	.5	2.7
In sand 6 "	4	0.0	.7	3.0	1.7	.5	0.0	5.9

Considerably more germination took place when the seeds were given some soil covering. In Table 2 please note the percentages one year after planting. There was practically no difference between the seeds which had been covered with a $\frac{1}{2}$ inch clay or $\frac{1}{2}$ inch of sand, nor in these two soils at 1 inch deep.

By reference to Table 1 again, please note that the germination on top of clay sod continued at about the same level for the first three years, and that there was very little germination after the first year for the other treatments. I find it difficult to explain why the clay sod would have such an influence on the viability of these seeds.

The total germination at the end of 6 years was not much different when the seeds were planted in a $\frac{1}{2}$ inch of clay or sand or even at 1 inch in either of these soils. Between the second and third inch levels there was a bigger drop in the germination percentage. At the first year interval 33.5 percent more seeds germinated through 2 inches of sand than germinated through 3 inches. This big difference is still maintained at the 6-year interval. It would thus appear that very few seeds germinate from depths lower than 2 inches. It is suggested that earthworms were responsible for bringing a few of the seeds from the 5 and 6 inch levels up closer to the surface, as none of the seeds germinating in these levels had stems much deeper than 3 inches.

These data would indicate that the main germination surge takes place within the first 3 years after the seeds have dropped, as very little germination was recorded in the succeeding years. In an attempt to learn what had happened to the balance of the seeds, a few of the plots were dug and carefully sieved. By this means, apparently sound seeds, those which had been injured by insects, and parts of the empty shells left by the germinating seeds were recovered. By adding the germination plus the apparently sound seeds recovered and the insect injured seeds, a few of the seeds were unaccounted for. In the plots sieved one year after planting, 24.4 percent were missing. This figure increased to 28.5 percent after 3 years and to 39.0 after 4 years. It is interesting to speculate as to what could have happened to these missing seeds.

As a good proportion of the pieces left when the seeds germinate were recovered, it does not seem likely that many were lost in the sieving process. A few might have been carried down deeper into the soil by earthworms, but this number would be small as only 3 seeds germinated in subsequent years after the soil from the top of three plots had been carefully sieved. On one occasion when the plots were being dug, the soil was taken up in inch layers and each layer handled separately. No seeds were found in the inch of soil below the depth at which seeds had been planted originally. The dead seeds or those not ready to germinate should all have been recovered - if they were still recoverable. The fact that this percentage of unrecovered seeds gradually increased as the time lengthened suggests that some unknown factor caused complete disappearance. This factor is benefited by more time.

As the seed coats are quite hard, it is not likely that fungi destroy many of them, but a few which are attacked by insects during the first year might possibly be disintegrated after 4 years in the ground. The fact that the percentage of apparently sound seeds recovered gradually decreased as the time lengthened would indicate that something is attacking these sound seeds and causing their complete disappearance. If we admit that a small percentage are missed or lost in sieving, it would be reasonable to expect that this percentage would be fairly constant instead of gradually increasing. Therefore, the increasing percentage of unrecovered seeds must have been caused by some other agency.

A suggestion, which will have to be given some consideration, is that small rodents, such as field mice, discover and eat the sound seeds. As the seeds in question were only planted $\frac{1}{2}$ and 1 inch deep, this suggestion seems possible and would explain the increasing percentage of unrecovered seeds.

Now, let us consider the practical application of these observations. Possibly the first thing that caused some surprise was the fact that germination can occur as early as April 15th and as late as October 20th, under our conditions. However, the main bulk of the germination always occurred in the first 3 months namely, May, June and sometimes July. There was a suggestion, but nothing more than a suggestion, that the germination date is earliest (May) during the first 2 years after the seeds fall, then the germination is later (July) for the 3rd and 4th year, and occurs one month earlier than this (June) during the 5th and 6th year. Admittedly, there are several factors which could influence the time of germination each year.

Possibly the most important observation from these data is that, with the exception of the clay sod, very little germination occurred after the 3rd year. There is evidence to indicate that even a 2-year spraying program along a roadside has given satisfactory control of ragweed. If the seeds receive some covering, approximately 60 percent germinate the following year. The germination is a little higher in or on sand and few germinate from lower than 2 inches in the soil. After a period of 4 years in the soil hardly any seeds were recovered by sieves and it is suggested that they had rotted away.

STUDIES IN WEED CONTROL

Thomas J. McMahon

"The ploughman homeward plods his weary way
 And leaves the world to darkness and to me."
 Grey's ELEGY

"You shall know the truth and the truth shall make you free."
 John: 8:31

Today it appears one may not engage in the field of weed control without first being a combination educator-public relations expert. Five years ago, I wrote a paper which called attention to the need for an understanding of the bio-chemists public relations problem. The paper was not published because, as the biochemist editor said in what I thought was a rather superior fashion, the subject was outside the scope of the agricultural chemical field. The scientist could not be concerned with these matters.

Subsequent to this decision, I wrote to the National Agricultural Chemical Association's P.R. man Jack Dreesen and suggested that either the scientists had better attend to public relations or the politicians would take over the scientists. Mr. Dreesen did his best. He came to Binghamton and studied the things we had done in creating acceptance for the work we do, but, though he sought funds to do the job, he was not successful, for just as the man who decided on the papers understood only biochemistry, so also did the men who headed the industry understand only the scientific aspects.

What the industry failed to see and understand was the magnitude of the work in which they were engaged. The industry did not see that when progress of such magnitude is suddenly thrust upon the public without adequate education, a vacuum is created. When this vacuum occurs, it attracts the opportunists. But these opportunists are attracted by more than the vacuum. They are attracted by the great concern which has been created by this new activity. They see that massive public with its paranoic tendency to view with suspicion and distrust that activity which is performed in comparative silence on such a broad scale.

Coupled with this general condition, there is what Freud called the "insult." The "insult," the discovery, is a deep wound to human pride. People, for example, did not cheer Copernicus when he proved that the earth, instead of being the center of the universe, was merely a speck in the Galaxy. They hated Copernicus for this "insult" and he was ridiculed with a "glee" which always accompanies this belittling of the discoverer and his discovery. Freud called Darwin's biological evolution theory, the biologic insult. He called his own theory, the psychologig or psychoanalytic insult.

In the life of many, there have been the motor car insult, the airplane insult, radio insult, and the like. Who remembers the reference to the "Tin Lizzie" when Henry Ford started his mass production, his assembly line, his eight hour day, his minimum \$5 per day wage? Or the "I'll fly if I can keep one foot on the ground." Or, "Is radio here to stay?"

What the biochemical world has failed to see is that perhaps the greatest "insult" of all has been rendered, The Chemical Insult.

Down through the years man has watched the phenomenon of growth with great awe. Darwin gave considerable attention to this problem, but he established, for example, that whatever caused plants to bend toward the sun took place in the tip of the leaf. The very mystery of this growth gave man a certain occult delight. He studied and gave names to the parts of the plants. He described their actions and their functions. He saw the roots as taking nutrients from the soil. He ridiculed DeCondelle near the time of Darwin when DeCondelle suggested that the roots might exude something into the soil. He saw the inter-relationship of plants, compatibilities and competitions, He saw many effects; he found few causes. But more than that, he thought material causes could not or would not be known. This unknowable nature was a joy to man. This land of mysterious growth was the forever wonderland. And there was for man in this impenetrable nature a kind of aesthetic emotionalism which gave wings to the imagination and permitted a free flight unfettered by the ordered laws of a science.

Until one sees the state of mind which this traditional concept of growth had engendered, he does not begin to see the depth of human pride which was not merely insulted, but shocked beyond words when that Dutch botanist, F.W. Went, in 1926, proved for the first time in the history of mankind that growth is caused by a chemical compound. It was Went who, with his Avena Test, proved this fact by causing plants to bend in total darkness. But the little Dutch botanist from St. Louis Botanical Gardens also developed a means of measuring the presence of chemicals which occurred in such minute quantities no known measuring device heretofore had been capable of determining.

What was surprising in 1955 was that the name F.W. Went was little known. Such a major breakthrough in the agricultural field would seem to merit major attention. Only a small group of research scientists appeared to take note of Went's discovery.

In 1942, the issue of the growth control chemical, beta-indolylacetic acid, was catapulted into the biochemical world when Drs. Zimmerman and Hitchcock discovered at the Boyce Thompson Institute that 2, 4-dichlorophenoxyacetic acid possessed all the characteristics of the naturally occurring growth chemical. The 2, 4-D could be produced in quantity, whereas, the plant growth control chemical occurred in such tiny amounts in a single plant that it was impossible to consider its widespread use. In 1944, Drs. Hamner and Mitchell discovered that by increasing the strength of the 2, 4-D, weeds could be controlled. The

effect of this discovery was to send a number of industries into massive production and promotion of the "miracle" chemical. By 1946, the production was in full sway.

Instructions on control of application were completely ignored. And the "brown-outs" which occurred,.. the damage from drift to desirable crops,..the volatility from hastily concocted formulations,.. all these errors gave the "insulted" an abnormal supply of "glee" material. What should have been heralded as a national scientific advance was treated as a national catastrophe. Companies which had rushed to produce the materials as quickly dropped out. The chemical and the chemicals were debunked with the utmost "glee," in true Freudian pattern.

And while this was all going on, insecticides, miticides, and fungicides were being developed in this chemical breakthrough which began with Mueller's DDT discovery at Geigy about 1940 and Disweal's discovery at DuPont in 1943. Research went on at a furious pace, but the total meaning of all these discoveries in this biochemical gold rush was lost to the newspaper and magazine writers in the awesome explosions of the atomic and hydrogen bombs. Fall out of Strontium 90 and the alleged fatal effects on this and subsequent generations attracted public attention. The effect of fluoridation of water on the body enzymes and the mottling of teeth and the alleged effect of enervation on the public took considerable attention. Political and foreign relations activities also contributed to this occupying of public attention.

But the obscurity in which the biochemist had progressed through these years was not entirely without incident. Arthur Fleming had created a furore in the cranberry incident which reached a ten million dollar conclusion in New England with the government's purchase of the cranberries which were dumped into an old gravel pit, an event, by the way, which subsequent authoritative writers failed to mention to the public which, they say, has ".. the right to know .." And there were a number of brush fire wars such as in Connecticut and New York. But no one would admit that there was any force to these people who were so obviously, to the biochemist, out of step with progress.

There were other signs of the "insult" reaction in the lawsuit on Long Island which, though the government scientists won, did not contribute to public understanding.

Yet what a wealth of amazing scientific discoveries were coming out in that period. Went had proved that growth is caused in a plant by a chemical compound created by the action of the sun on the tip of the leaf; Zimmerman and Hitchcock had come up with the synthetic of the growth chemical. Martin and others in the orange groves were discovering that the dead roots of old trees give off chemical compounds to the soil which inhibit the growth of new seedlings. Similar discoveries followed on old peach and apple orchards. Land which for years farmers had considered to be "worked out" suddenly was restored to full productivity by treating with chemicals which neutralized the inhibiting compounds. Oswald in Sweden proved that the roots of red fescue give off a chemical compound in whose presence the rape seed will not germinate.

An examination of these discoveries led Dr. L.J. Audus, Botanist at the University of London, to write, "There can no longer be any doubt but that a wide range of roots and underground stems give off chemical compounds which are growth inhibitors." In short, in that period which began with Went in 1926 and ended with Dr. Audus's statement in 1953, the greatest and most far reaching botanical, agricultural, and ecological discoveries in the history of mankind had been made. Down through the ages history records nothing to indicate that man had ever reached such a knowledge of the truth of growth.

But here was the total fact of growth and soil condition and the truth was it is all chemical. Chemicals are the agents by which growth is achieved. Chemicals are the agents by which growth inhibition is accomplished in nature. Around every seed there is a chemical growth inhibitor. The inhibitor around the lettuce seed is broken down by light and heat. That is why it must be planted very shallow. The inhibitor around the apple seed is broken down by 60 days of moist cold.

Radishes exude from their roots a chemical compound which inhibits the growth of spinach; and spinach gives off a chemical which inhibits the growth of the radish. That is why radishes and spinach never do well when planted side by side. They are mutually antagonistic, but the antagonism is chemical.

Ragweed will not pollinate unless it has the required hours of darkness. That is why ragweed growing under a city light does not throw up a pollen head. It is photosensitive.

Water on the leaf of the desert plant, *encelia farinosa*, creates a solution of a chemical compound new to science which inhibits the germination of all other seeds. That is why no other plant will grow under this desert shrub. Pine needles give off a chemical compound which inhibits germination of other growth. That is why nothing else grows at the base of trees in a pine forest.

Grasses around the base of an apple tree reduce the productivity of the apple tree. Weeds in a cornfield will reduce the yield of corn by one third; in a wheat field, by twenty-five percent; in an oat field, by twenty per cent. Weeds in farmer's crops cost the consumer \$33 per year.

Rye and wheat beards are poisonous to many farmers. The "dust" from threshing machines will poison many farmers. Nature is not a harmless friendly environment.

The wealth of knowledge the biochemist has in our day wrested from nature is even now unending. But, unfortunately, his discoveries have occurred in a field where the bacterial-type scientists with their followers constitute to a great part, not so much a science, as a cult, which has been rendered a tremendous "insult." And the "insult" has been so vast, so unrelenting, so continuing that those who have made their livelihood as experts in this field have been totally overwhelmed by the silent progress which has relegated them to another era. Only those who have been active in research could possibly have

kept pace with the rapid moving field of biochemistry. Man has, in truth, discovered nature's methods of plant and insect control, and nature's method, the bitter truth is, is, "It's chemical." And the greatest horror of all is all this time even the bacteria are nothing more than little chemical plants converting compounds into elements or into other compounds which the plants can then utilize.

Public Relations is that science which considers the nature of human reaction to new and old discoveries and devises ways, means, and methods of presenting effectively these discoveries to the public that they may be so understood as to be accepted; that they may be used intelligently; and that the scientists who have developed these advances may retain that environment which will continue to permit the necessary freedom to develop further these advances. Public Relations is public education, not manipulation. The true scientist has no need for manipulation of public opinion. He requires only a forthright presentation of facts to the public.

But when there is delay in letting the public know fully these facts, this vacuum is created and the opportunity is presented for manipulation. Manipulation is an employment of persuasive techniques to achieve a self-serving end not consistent with logical conclusion from consideration of all the facts. Manipulation is achieved by partial or slanted presentation. Where there is the conscious and wilful omission of facts, there is intent to manipulate. Omission, however, can develop from paranoid tendencies. In either case, the effect of manipulation is achieved.

"Facts," the educator said, "are the tools with which we think."

As you now listen to me, ask yourself: Have I considered all the facts? Do I possess all the facts? Why do I believe what I believe? Whom or what do I serve with my belief or my opinion? Am I acting with right reason? Why? How do I know? What are the facts?

Think again. The facts are these:

1. The truth of all growth is chemical. Chemicals are the agents which cause certain actions and reactions.
2. Some chemicals cause growth.
3. Some chemicals retard growth.
4. Some chemicals prevent growth.
5. Some chemicals regulate growth.
6. The growth chemical, beta-indolylacetic acid, is caused by the action of the sun on the tip of the leaf, and only on the tip of the leaf. This acid causes cells to elongate and divide. This action is growth.

7. This chemical in the tip of the root regulates the rate of growth in the root. If the tip of the root is cut off, this regulating control is destroyed and the root will extend itself rapidly.
8. The roots of plants take nutrients from the soil; these nutrients are chemicals.
9. The roots of plants and many stems exude chemical compounds to the soil; these compounds differ from each plant and are specific growth inhibitors. These exudations occur in a wide variety with effects of varying conditions.
10. The leaves of many plants washed in the soil release growth inhibiting chemicals.
11. Around the pod or shell of every seed there is a chemical growth inhibitor. This chemical varies with each plant seed. It is the difference in each seed which accounts for the difference in time of germination.
12. The emanations from a number of plants are growth inhibiting chemicals.

One might say that these are the principles derived from the botanical discoveries of this century. Since the turn of the century, man has discovered the truths of growth which have been hidden from him since the dawn of history. These truths are chemical and completely revolutionize agronomy, botany, and all related fields.

Just as the philosopher and the theologian have resisted the intrusion of the psychiatrist and psychoanalyst in the field of human mental health and happiness, so has the botanist resisted the intrusion of the chemist into the world of botany. But it is evident that one must make room for the other. These discoveries require they must live together in the new field of biochemistry.

The spectacle of conflict between humans must not be permitted to be regarded by the public as a struggle between the good scientist fighting the bad scientists. The truth is the insulted scientist, caught in these startling advances, is reacting in the manner of the insulted and is trying to bar the discoverer from reducing the stature and the position of the man who wishes to retain his status quo. One suspects that he has restored to the technique of manipulation whereby a public is caused to be alarmed to such a degree that any further advances are made to appear as threats to the public welfare.

As you listen to these words: What do you believe? Do you believe that certain unscrupulous public officials and certain unscrupulous university scientists are conspiring with a certain segment of unscrupulous businessmen to poison you for profit?

Or do you believe a responsible group of scientists has finally solved the mysteries of life to such a degree that considerate and responsible public officials are placing approval on these advances that the public may have the advantage of scientific truth and that businessmen, acting in good faith, believing these scientists and officials are risking venture capital in the belief that the public will buy these new discoveries?

What is the reasonable belief in the light of what you now know about what has been discovered since 1900?

Do you believe that man is coming to know the truth which is making him free? Do you see our time as part of the fulfillment of Christ's prophecy? Or do you think we should remain with Grey in the Churchyard eternalizing the conditions which led to his lines:

"The ploughman homeward plods his weary way
And leaves the world to darkness and to me."

State of mind . . . this is part of a study in weed control. Are you the freed? Or the condemned?

CONTROL MEASURES UNDERTAKEN TO PREVENT
UNNECESSARY SECONDARY POLLUTION OF WATER
FROM CHEMICAL AQUATIC PLANT CONTROL

George W. Starbuck¹

INTRODUCTION

This paper is presented to show what control measures Vermont's Department of Water Resources has adopted to help eliminate adverse secondary pollution of the waters from chemical aquatic plant control. Before explaining the control measures, however, it is necessary to explain the present problems of aquatic plant nuisances in Vermont and the nature of secondary pollution.

EXTENT OF AQUATIC PLANT PROBLEMS IN VERMONT

At the present time, Vermont's aquatic nuisance problems are moderate, but the Department of Water Resources does not want to see the problem increase because of the extensive use of Vermont waters for all forms of recreation.

Recent studies have shown that there are approximately 51,273 acres of water in lakes and ponds of 20 acres or more in size in the State of Vermont, which figure does not include any area of Lake Champlain or that portion of Lake Memphremagog (an international water shared with Canada) in Vermont. Assuming that an average of 5% of the surface area of all ponds in the state contain aquatic vascular plants to such an extent as to cause a nuisance, there are approximately 2,500 acres so affected. It is further estimated that approximately 1,000 acres of aquatic vascular plants cause a nuisance in the Vermont portions of Lake Champlain and Lake Memphremagog. Hence, there are approximately 3,500 acres of water in the state where aquatic vascular plants create a nuisance. When this figure is compared to other areas of the country, it would appear that the State of Vermont has relatively fewer problems in this field. Further, not all of the 3,500 acres are so heavily populated with aquatic vascular plants as to render these waters completely useless. A large percentage of this water area is not inhabited by floating or emergent vegetation, but by submergent varieties, many of which are in deep water and do not approach the surface. Among the submergent plants, the prime nuisances are Potamogeton spp. and Myriophyllum spp., although Vallisneria americana, Elodea Candensis and Ceratophyllum spp. may cause problems when they break off or become uprooted and float ashore. Other vascular aquatic plants cause problems in limited areas throughout the state. It must be emphasized that the above data are purely approximations based not upon actual surveys but on estimates compiled by the staff of the Department of Water Resources.

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There are several areas in the state, exclusive of farm ponds, that play host to algae growths at various times during the year. One major area is St. Albans Bay, a 1,750 acre bay in the northern sector of Lake Champlain where the bloom producing algae are primarily Anabaena spp. On the eastern side of the state, Lake Morey and Halls Pond show growths of Gloeotrichia spp. in mid-August of each year. The presence of these blooms in such areas as those just mentioned has severely limited the use of the water for recreational purposes, but most other lakes in the state do not have severe annual algae problems.

Undoubtedly, a short growing season and the lower temperatures of the waters in the State of Vermont greatly help to alleviate some of the aquatic nuisance problems. In view of these facts, it may be admitted that technically the problem in Vermont is not as severe as that in other states, but the problem, nevertheless, does exist, does cause difficulties with the full utilization of Vermont waters, and is one which must be approached and eventually solved.

SECONDARY POLLUTION

Since there are areas in the state that may require chemicals to control aquatic nuisances, the Department of Water Resources has adopted procedures to minimize unnecessary secondary adverse pollution of the waters of the state. Secondary pollution of the water results when algicides and/or herbicides, which are applied for beneficial purposes, cause unwanted changes in water quality and biological systems. Examples of such secondary pollution are:

1. Algicides and herbicides can cause fish kills by direct toxic effects;
2. The oxygen depletion resulting from the decay of aquatic plants killed by algicides and herbicides can be so severe as to cause suffocation of fish and other organisms;
3. The oxygen produced by aquatic plants is sometimes the only source of this vital gas when small ponds are covered with ice in the winter; hence, removal of plants by herbicides under these circumstances could result in the death of fish by oxygen depletion;
4. Algicides and herbicides may cause changes in natural populations of aquatic organisms other than those for which the treatment is intended, as the removal or reduction in the population of one or more species of organisms from an aquatic community can produce profound changes in the populations of other species. When aquatic plants are used as protective cover by many species of fish, the removal of the plants results in greater exposure of the fish to their natural enemies. At sometime or other in their life history, nearly all species of fish feed on aquatic insects, many of which feed on aquatic plants and/or algae. Hence, the removal of aquatic weeds which are used for food by insects indirectly reduces the number of

fish a body of water can support.

Generally, when algicides and herbicides cause any of the above, they have created secondary pollution of the waters because these changes are not normally desirous. On occasion, the above conditions are the result of erroneous calculations of areas, water volumes or the amount of chemical to be applied while at other times they are the result of a deliberate addition of too much chemical (overdose), or the use of a chemical that is not designed to control the vegetation to which the chemical is applied. Other causes such as machinery failure, untimely application of chemicals, a failure to understand the problem or improper identification of the aquatic plant material present and needing control may also cause difficulties.

CONTROL MEASURES

The Department of Water Resources has not been directed by specific legislation to control "weeds" and algae, but does have a prime interest in aquatic plant control because of the secondary pollution which may occur.

As defined by the State of Vermont and similarly by many other states, pollution of water means: "the placing in the waters of the state by whatever means of any noxious or deleterious substance which renders such waters harmful to animal or aquatic life, or to use for industrial purposes or for recreation." (1) Hence, in Vermont, the addition of chemicals to waters to control aquatic plants does constitute pollution, as the legal definition does not attempt to differentiate between beneficial or nuisance aquatic life. In the absence of specific legislation assigning the regulation of the use of chemicals for aquatic nuisance control elsewhere, the Water Resources Board and the Department of Water Resources in the State of Vermont considers that since they are by law responsible for the overall quality of waters in the State of Vermont, such control problems are a Department responsibility, under the water conservation policy which reads: "It is hereby declared to be the policy of the state that the water resources of the state shall be protected, regulated, and where necessary, controlled under authority of the state in the public interest and to promote the general welfare; and it is further declared that said policy necessitates the creation of a state agency, which shall be known as the Vermont State Department of Water Resources" (2) Further, the Board interprets the placing of herbicides and/or algicides in the waters as a form of pollution within the legal definition. Since Vermont law further requires that a person desiring to create a new source of pollution petition the Water Resources Board for a permit, the Board has adopted the policy that application of chemicals for "weed" and algae control cannot take place without said permit. (3)

In order to develop a control system, the Pollution Control Division of the Department of Water Resources sent questionnaires to 49 states, 38 of which answered. Based on these questionnaires, the Pollution Control Division has developed its present procedures and programs to protect the waters of the state and to control unnecessary secondary pollution. A permit system, administered in the manner as that dealing with more conventional sources of

pollution, enables the Division to keep an accurate record of the amount and type of chemical applied to each body of water in the state. A person desiring to control aquatic nuisances by the use of chemicals must petition the Water Resources Board for a permit to place the chemicals in the water.

Upon receipt of a petition for a permit, the Pollution Control Division undertakes an investigation which entails the following aspects felt to be critical in controlling unnecessary secondary pollution.

First, a biological survey is conducted at the proposed treatment site at which time the aquatic plants present are recorded and many specimens are pressed and mounted for a permanent record. In addition to the treatment area itself, observations are undertaken and information recorded on adjacent areas, so as to gain information on plant movement and regrowth after chemical application and control. In addition to the biological survey, a contour map is made of the area, the surface area is calculated from maps, and the treatment plot is surveyed if necessary. All of this information serves as the basis for calculation of the amount of chemical to be applied. Every attempt is made to make the investigation as complete as possible. All calculations are checked so as to minimize any errors that could arise from miscalculations of volumes or areas of water and dosage of chemicals. During this time, an overall evaluation is made of the chemical to be applied and the control that can be obtained with the aquatic vegetation present. Many times, because of the small area needing control, this investigation shows that mechanical removal, such as raking, cutting, filling in with sand, and where possible, complete removal from the water, is more economical and would result in better control. Upon completion of this investigation, a report is made by the staff to the Board and the Board may issue a permit if it feels that to do so would be in the best interests of the public. This report then becomes part of the permanent records. The importance of permanent records cannot be overemphasized in order to evaluate future control projects, and for information concerning future adverse secondary pollution that may result as the result of the chemical control applied. For example, should there be a change in a ecosystem, the records may be referred to and the change explained and possibly avoided in the future.

Second, during the investigation, the staff biologist of the Department of Water Resources meets with the applicant to discuss his findings. An important purpose of these meetings is to educate the people to the problems of chemical aquatic plant control and to explain the necessary precautions. During these meetings, it has become apparent that many individuals completely misunderstand the problem. Hence, the Department has undertaken an educational program aimed at establishing the following points:

1. The importance that aquatic plants play in nature and the ecosystem;
2. An explanation of why aquatic plants are present in the waters and what causes aquatic plants to grow in abundance in some areas; and
3. The fact that control is a much more realistic measure than complete eradication.

Experience since this educational program was undertaken has shown that a realization of the problem has resulted in cooperation. For example, residents of Lake Morey were willing to delay a control project of Gloeotrichia sp., which did not constitute a severe problem, in order to avoid the establishment of other, more noxious or deleterious algal species.

Third, the Pollution Control Division exercises personal staff supervision of every and all known applications of algicides and herbicides to the waters of the state. This supervision includes checking the weight and/or volume of the chemical applied, as well as chemical analyses of the water before, during, and after treatment to determine, where possible, the concentration of active ingredient that has been produced in the water. Also, during the actual application, careful checks are made to see that the chemical is being applied in the correct concentration, if dilution is a factor, and that it is applied uniformly over the treatment area. When chemicals are applied in the solid state, the chemical is divided into four portions and each portion is applied uniformly over the entire treatment area.

Finally, after treatment of the area, weekly observations are made so that an accurate record can be obtained of the rate of control, the residual effect of the chemical, and the species of plants that survive the treatment. The information obtained from such past observations is used to make possible a better evaluation of future projects.

NEEDED PROGRAM IMPROVEMENTS

In spite of the precautions presently undertaken by the Department of Water Resources, there are some areas where it is felt the program of aquatic plant control should be strengthened in the State of Vermont. Future needs include specific legislation dealing with aquatic plant control, which has been drafted and will be presented to a special session of the Vermont Legislature in early 1964. This legislation is not an amendment to existing laws but a completely new set of laws dealing with pollution control, one section of which, in its presently drafted form, would give the Water Resources Board, among other powers, the authority to: "Issue permits when, in the public interest, upon petition relative to the introduction of algicides, herbicides, and insecticides to the waters of the state to control aquatic life."

In addition to this, these new pollution laws would also give the Board the authority to make and promulgate rules and regulations. With these laws and its subsequently adopted rules and regulations, the Board will have direct control over the use of algicides and aquatic herbicides. Upon successful passage of this proposed legislation, the Board expects to change and strengthen the permit system, by the adoption of standard application forms, calculation sheets, and official permit forms, which will be used to keep an accurate record of all control programs undertaken.

Another needed project scheduled for the future is a series of seminars to be conducted by the Department of Water Resources and to which will be invited other state departments, university officials, the Vermont Extension Service, and other interested individuals. By means of such meetings, it is hoped that duplications of studies can be eliminated and a better exchange of knowledge in the field of aquatic plant control can be achieved. One of the main subjects needing discussion are further control measures that the state should assume to prevent unnecessary secondary pollution of the waters.

CONCLUSION

The Department of Water Resources recognizes that there are areas in the State of Vermont that have aquatic nuisance problems needing control. At present, it is possible with the existing staff to completely control and supervise each and every project. By means of the permit system, biological surveys, education and supervision, it has been possible for the Department of Water Resources to eliminate some of the unnecessary secondary pollution of the waters of the state. It is hoped that in the future a better understanding of the problems can be realized by the people in Vermont, and it is felt that this can be accomplished by the use of present procedures, further education of the people, and complete coordination and cooperation with the general public in the field of aquatic plant control.

LITERATURE CITED

1. Title 10 of the Vermont Statutes Annotated, Section 901
2. Title 10 of the Vermont Statutes Annotated, Section 571
3. Title 10 of the Vermont Statutes Annotated, Section 910

Princeton University has endeavored to control this noxious vegetation with weed cutters and the application of various herbicides since 1955. Either due to the inability of the herbicide to control the vegetation or the excessive stream flow, the problem became acute in 1962.

A survey of Carnegie Lake was conducted by Consulting Biologists, Inc. to more fully explore the composition of the aquatic vegetation, the problems in the lake and to determine whether or not aquatic weed control was possible. The survey revealed that if the lake was to be used for rowing, the following plants must be reduced:

Coontail	<u>Ceratophyllum demersum</u>
Panwort	<u>Cabomba caroliniana</u>
Water milfoil	<u>Myriophyllum heterophyllum</u>
Pondweed	<u>Potamogeton epihydus</u>
Pondweed	<u>Potamogeton nodosus</u>
Pondweed	<u>Potamogeton pulcher</u>
Elodea	<u>Anacharis canadensis</u>
Eelgrass	<u>Vallisneria americana</u>
Spatterdock	<u>Nuphar advena</u>
White waterlily	<u>Nymphaea odorata</u>

The major problem was one of water flow. Based upon U. S. Geological Survey data, the average flow passing over Carnegie Lake dam is 145 million gallons per day. This flow represents 53% of the storage capacity of the lake. This flow would have to be curtailed if any weed control program was to be attempted.

PROCEDURES

Princeton University was desirous of weed control provided all the technicalities were handled by Consulting Biologists. To carry out aquatic weed control measures for a lake of this size, every precaution must be taken to see that everyone who might be affected by the introduction of a toxic material is notified.

The major concern was one of lake draw down. In order to control the flow, some twelve lakes had to be lowered 12-18 inches. These lakes were located in the following municipalities: Cranbury, Grovers Mills, Hightstown, Princeton and Rocky Hill. To obtain permission to lower these impoundments, all the above municipalities were personally contacted. In addition to those, final authorization rested with the N. J. Department of Conservation & Economic Development and the Stony Brook-Millstone Watersheds Association. Everyone expressed a willingness to cooperate: The U. S. Geological Survey granted us permission to enter their gauging station to check on stream flow, Princeton University would notify interested persons and agencies of their reasons for weed control and their

interest, and Consulting Biologists would be responsible for lake draw downs and application of the herbicide.

The herbicide to be used had to have the following:

1. Ability to hydrolize quickly in order to reduce contamination downstream.
2. Low toxicity in order to prevent fish kills and/or damage to other wildlife.
3. Wide spectrum of control.

The herbicide selected was Aquathol Plus, manufactured by Pennsalt Chemical Corporation.

Of the twelve lakes to be lowered only four were drawn down. Farmers and/or nurserymen, just prior to application, had reduced most lakes to no overflow, due to heavy irrigation, and they indicated that the irrigation would continue due to an early spring drought.

Just prior to application, local police and health agencies were contacted to inform them of the starting date and to request their assistance in patrolling the lake shore to ask fishermen not to fish until three days after treatment.

The herbicide, some 42,200 pounds, was applied during the last week in May by helicopter, supplied by New Jersey Helicopter Airways, Trenton, N. J.

RESULTS

One month after application, as additional 9500 pounds was applied in the vicinity of the Millstone Brook inlet area. The reason for retreatment was that dilution by this river had provided only limited control of Cabomba carolinana and Ceratophyllum demersum. None of the emergent vegetation, such as spatterdock, was effectively controlled; however, the rowing area had been freed from weeds. Future examination in the fall indicated that regrowth was present in the inlet stream areas, and that the rowing course remained relatively weed free.

CONCLUSIONS

The treatment of Carnegie Lake was successful from the standpoint of the number of weed species destroyed, resulting in an uninterrupted rowing season and also it demonstrated the necessity for cooperation among many agencies to provide this control. Operation Carnegie could not have been accomplished without the assistance of Princeton University, whose officials also realized that chemical weed control is only a stop gap method until more permanent methods are employed in renovating the lake, U. S. Geological Survey, U. S. Soil Conservation Service, Stony Brook-Millstone Watersheds Association, N. J. Department of Conservation and Economic Development, and the numerous lake owners and municipalities.

ALGICIDE APPLICATION AT THE WORLD'S FAIR

R. E. Sheridan¹

In the late Spring of 1963, our firm was contacted by Hazen and Sawyer, consulting engineers for the World's Fair. We were asked to describe our method or methods of algae control, providing a general description of spray application as compared to the generally used procedures of copper sulfate application.

In reply to this request, we presented information on our method indicating our capabilities of providing a flexible solution to their problem. Because of specific factors involved in the treatment of the World's Fair lakes, no ordinary methods of control could produce or accomplish the desired results.

A list of the major factors involved in the treatment of these lakes is as follows:

1. large amounts of nutrients in the waters
2. the time element for application
3. bottom sediment and shallow waters
4. rapid loss of active materials
5. protection of the fish population
6. high alkalinity of waters

The purpose of this paper is to present each of these problems in more detail followed by our solutions to each.

1. Because considerable amounts of nutrients necessitate frequent applications, our equipment had to have a great deal of mobility.
2. Dependability and mobility had to be provided due to the time element involved. Since the Fair would open to the public at 10 A. M. daily, application had to be concluded on Meadow Lake by that time. Thus, we had to provide a system capable of efficient use of available time, a system with the potential of counteracting any extenuating circumstance in stride.
3. Due to the ease with which bottom sediment was disturbed, a less turbulent method of propulsion would be necessary. In conjunction with this, the extensive shallow depth required the elimination of any projection below the boat.
4. Following from point three, the turbulence also decreased the residual copper after application, since the copper sulfate would tie up with this agitated material, reducing the action on the algae and necessitating increased dosage to arrive at a desired result.

5. As a result of the increased dosage required, the problem of providing adequate protection of the fish population arose.

6. The last major factor involved was the unusually high alkalinity found in the World's Fair lakes which compounded the dosage problem.

Our solution to each of these problems is as follows:

1. Mobility was solved by providing a system that was self-contained, easily transferable and ready for use without extensive preparation.

2. The time factor was solved by providing a system that allowed for varying speeds, patterns, and solutions. The speed can be regulated with a great degree of precision from zero to twenty-five miles per hour. The spray pattern, through the use of "boom jets" allows a variation in width up to sixty feet with instant control of the pattern on either side of the boat. The solution can be controlled in the mixing tanks by adjusting a simple regulating valve and through the use of a flow meter. The quantity of liquid in the tanks is further regulated by a float valve.

3. Projections extending below the boat and turbulence by underwater propulsion were eliminated through the use of an air motor.

4. The loss of copper sulfate due to its tie up with bottom materials was also solved by removing the source of turbulence, e. g. underwater propulsion.

5. Greater protection was afforded to the fish population because less chemical was now necessary to achieve the desired residual of copper in the water, since chemical tie up with bottom materials was eliminated. Further protection was provided by the usual division of the lakes into sections, the first and second sections being on the opposite ends of the lake.

6. The problem of high alkalinity was solved by recognizing the diurnal characteristics of alkalinity in water and providing for application early in the morning when the PH was still fairly low.

The inter-relationship of the above factors can be readily seen since the solution of one generally facilitated the solution of another. The control provided by this new method can be graphically illustrated by comparing the following tests made with the standard procedures and the new method of application on the lakes.

The factors involved in the comparison are as follows:

	<u>Old</u>	<u>New</u>
1. Method of application	a. standard	b. spray
2. Propulsion	a. outboard motor	b. air motor
3. Agitation of bottom deposits	a. substantial	b. minor
4. Pounds of copper applied	a. 14,350	b. 11,300
5. Total cost	a. \$2,858.00	b. \$2,422.00
6. Residual copper after 24 hrs.	a. (1) 0.83 (2) 0.60	b. (1) 1.00 (2) 1.08

Several important factors may be determined by the above figures. By using spray application with an air motor, the initial dosage of copper would be decreased while still achieving the same desired result. Therefore, the initial cost of chemical would be much less. Secondly, by eliminating the agitation of bottom sediment, coupled with the spray methods, the residual copper found in the water was greater and persisted at a higher concentration for a longer period of time.

Thus, by providing a flexible system with a new method of application, the major factors preventing normal methods of adequate control were eliminated and increased effectiveness was provided at reduced cost.

ROBERT E. SHERIDAN & SONS

Robert E. Sheridan

OBSERVATIONS ON SOME ACID WATER LAKES TREATED WITH DIQUAT

Donald N. Riemer^{1/}

This paper deals with two chains of lakes of a type which is very common on the southern New Jersey coastal plain. They are typically small impoundments containing "cedar-water" which has a pH range of 4.5 to almost neutral. The water has relatively large amounts of finely dispersed organic colloids and a color not unlike that of weak ice tea. They usually have a sandy bottom which may or may not be covered with an accumulation of organic detritus.

Although these waters are quite unproductive from a fisheries point of view, most of them contain dense weed growth during the warmer months of the year which greatly impair their recreational potential and aesthetic value.

CHAIN "A"

The first chain of lakes, which will be designated as chain "A", consisted of four impoundments and a shallow swampy backwater on the extreme upper reaches of the Mullica River. The physical dimensions of these ponds were as follows:

	<u>Area</u>	<u>Average Depth</u>	<u>Volume</u>
Pond 1	2 acres	4.5 ft.	9.0 acre feet
Swamp	0.5 acre	-----	-----
Pond 2	8 acres	2.5 ft.	20.0 acre feet
Pond 3	2.5 acres	1.5 ft.	3.7 acre feet
Pond 4	6 acres	2.7 ft.	16.2 acre feet

The flow of water was from Pond 1, to the swamp, to Ponds 2, 3, and 4 in that order.

At the inlet to Pond 1 was a "weed trap" consisting of a series of three barriers, each designed to hold back material of a smaller size than the preceding one. The first barrier was a staggered double row of copper pipes protruding from the water and spaced about 6 inches apart. The next barrier was a row of wire baskets with a mesh size of about 1" x 6". The final barrier was a chicken wire screen with a 1/2" mesh. This "trap" was installed by the pond owner and was cleaned by him approximately three times each week throughout the summer.

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Benthic invertebrate samples were taken before and after treatment in order to determine whether or not fishfood organisms were affected by the diquat. These samples were taken by two means: the conventional Ekman dredge and the multiple plate sampler described by Hester and Dendy (1962). Plankton samples were also taken but the number of plankters was so small as to prevent a valid comparison between the before and after samples.

A 20 foot minnow seine was used to check on two schools of largemouth bass fry in Pond 4.

Treatment. The treatment in the entire chain of lakes was made on 3 June 1963 at which time the surface water temperature was 69°F. and the pH was 5.8. The herbicide was applied at the rate of 2 pounds of diquat cation per surface acre as recommended by Wessel (1963). Pond 1 was treated by throwing the herbicide into the water from the bank. The shallow backwater was treated by pouring the herbicide into the outflow of Pond 1. Ponds 2, 3, and 4 were treated by pouring the undiluted commercial product directly into the water from a moving canoe or rowboat.

The weed situations in the various bodies of water at the time of treatment were as follows:

- Pond 1: Sparse growth of bladderwort (Utricularia sp.).
Swamp: Relatively heavy growth of bladderwort.
A few scattered plants of spatterdock (Nuphar sp.).
- Pond 2: Very light growth of bladderwort.
One corner with a small stand of bur reed (Sparganium sp.).
- Pond 3: Relatively heavy growth of bladderwort.
Scattered patches of duckweed (Lemna sp.).
Large dense stands of bur reed.
Shoreline covered with decodon (Decodon sp.).
Scattered spatterdock plants.
- Pond 4: Scattered but dense patches of bladderwort.
Occasional small patches of duckweed.
Some decodon, cattail and bur reed along shoreline.

In previous years, bladderwort was reported as being very dense and by midsummer the lakes were considered useless for swimming and other recreational purposes.

Results. On 5 June, 2 days after treatment, the duckweed was completely dead and had a bleached, grayish-white appearance. The bur reed was turning brown from the bottom up. Some patches were completely brown with dry brittle leaves. The

water level in Pond 2 had been lowered the previous day and the patches of bur reed were left above the water line. This bur reed was just beginning to turn brown at the basal portions of the leaves.

The bladderwort in Pond 1 was completely white and starting to disintegrate. A slight turbulence of the water created with a stick or a hand was sufficient to break nearby plants into many fragments. In the remaining ponds, the bladderwort was not affected as severely, but many plants had growing tips which were whitish in appearance.

The cattail, spatterdock, and decodon remained unaffected throughout the summer.

Two schools of largemouth bass fry (Micropterus salmoides), which had been located on the day of treatment were observed again and appeared to be unaffected. Other fish observed on this date were a school of fingerling yellow perch (Perca flavescens), one pickerel fry (Esox sp.), and enormous schools of newly-hatched, unidentified fish which were probably minnows. All were apparently unaffected. Large numbers of toad tadpoles (Bufo sp.), and one baby redbelly terrapin (Pseudemys rubiventris), also appeared normal.

By 7 June, (four days after treatment) not a single frond of duckweed could be found--dead or alive. The bur reed had turned completely brown except for the patch which was left high and dry in Pond 2.

The bladderwort was only slightly more affected than it had been on 5 June, except in Pond 1, where nothing remained except small decaying fragments of the plants.

The same species of fish which had been observed earlier, still appeared normal and in addition, adult pumpkinseed sunfish (Lepomis gibbosus), were seen on nests in Pond 1.

During the next nine days the bladderwort in the ponds continued to become more and more discolored and to break up into smaller and smaller pieces. On 17 June the control of bladderwort in Ponds 2, 3, and 4 was estimated at 95-99%. In Pond 1, no bladderwort could be found at all. Along the margins of the swamp, however, this species was only slightly affected. On this date all of the bur reed was completely brown and was beginning to collapse and disappear. (The water level in Pond 2 had been raised again, probably reaching the bur reed sometime on 9 or 10 June.)

Length of Control. Satisfactory control of the duckweed, bur reed, and bladderwort was obtained for the entire summer season. No regrowth of bur reed occurred at all. Bladderwort and duckweed reappeared in Ponds 2, 3, and 4, probably as a result of being washed downstream from the swamp. The duckweed remained so rare that one had to hunt among the

shoreline grasses to find fronds on it. The bladderwort became more abundant but never reached problem proportions. As late as mid-September it occurred only in small scattered patches along the shoreline, mostly behind logs, stumps, etc.

The poor control in the swamp is attributed to poor dispersion of the diquat caused by the method of applications, (poured into the spillway of Pond 1) and lack of water circulation due to the presence of many dead trees, stumps, and fallen logs.

Pond 1 remained weed-free throughout the entire summer and up through the third week in September. This was undoubtedly due to the "weed trap" which captured many bushels of bladderwort throughout the course of the summer.

Benthos. Bottom dwelling organisms were sampled by two different methods as noted earlier in this paper. The Ekman dredge samples were taken on 31 May and 5 June. The multiple-plate samples were picked up on 3 June and 5 June after having been exposed in the water for 15 and 17 days, respectively. Twenty-eight multiple plate samplers were set out and 23 were recovered (12 before treatment and 11 after treatment).

The vast majority of organisms collected were dipteran larvae of the family Chironomidae. As a result, the total number of organisms was considered and then the number of chironomids was considered separately. A summary of the results is given in the following table.

Average number of organisms collected per sample.

	Before		After	
	Total organisms	Chironomids	Total organisms	Chironomids
Ekman dredge	57.75	45.25	81.25	79.00
Multiple plate samplers	188.3	165.8	212.2	184.5

Because there was a considerable amount of variability among samples, these differences were not significant at the 1% level. Even if they had been significant, however, they would have shown an increase after treatment--not a decrease.

CHAIN "B"

This chain of ponds consisted of three small impoundments in the southern portion of the Rancocas Creek drainage. They were similar in nature to the impoundments of Chain "A" except that there was less accumulation of organic debris on the bottom and the water was not stained as deep a brown color. The physical dimensions of the individual ponds were as follows:

	<u>Area</u>	<u>Maximum Depth</u>	<u>Average Depth</u>	<u>Volume</u>
Pond 1	0.77 acre	4.5 ft.	2.35 ft.	1.81 acre ft.
Pond 2	1.01 acres	5.5 ft.	2.09 ft.	2.11 acre ft.
Pond 3	0.97 acre	4.5 ft.	2.00 ft.	1.94 acre ft.

The flow of water was from Pond 1, to 2, to 3 in that order.

At the time of treatment on 7 June a dense mat of bladderwort blanketed the surface of all three ponds. No other weeds were present.

The ponds were treated by pouring the herbicide directly out of gallon jugs from a moving canoe. The rates of application were as follows:

	<u>Pounds of diquat cation per surface acre</u>	<u>Concentration in ppmw</u>
Pond 1	2 pounds	0.31 ppmw
Pond 2	3 pounds	0.53 ppmw
Pond 3	4 pounds	0.73 ppmw

The pH of the surface water at the time of treatment was 5.7.

On 11 June, four days after treatment, the following observations were made:

- Pond 1. Very little change in weed condition. A few weeds at lower end of lake seemed slightly paler in color.
- Pond 2. Plants were pale in color, were partially defoliated, and fragmented very easily upon being touched. A large mass of plants near the spillway had broken up and had been washed down into Pond 3.
- Pond 3. Except for the mass which washed down from the pond above, this lake contained only small fragments of defoliated stems. Pumpkinseed sunfish

On 17 June, 10 days after treatment, the ponds appeared as follows:

- Pond 1. Still very little difference in appearance of weeds.
- Pond 2. This pond was essentially open water with just a few small patches of bladderwort remaining in the center.
- Pond 3. This pond was weed-free for all practical purposes, except for the upper end where the weeds had washed in from above.

By 2 July, all three ponds were in the same condition. All that remained were a few tiny fragments widely scattered along the shoreline and a few larger plants rooted in the deeper parts of each lake. Control was estimated to be 95-99%.

On 4 September, a detailed search made by boat and by foot in all three ponds did not reveal a single piece of bladderwort. By late September, however, a few tiny plants reappeared in Pond 1. On 12 October, the regrowth in Pond 1 had not progressed much further and Ponds 2 and 3 were still weed-free. It is possible that the regrowth in Pond 1 was not due to the low rate of herbicide application, but to the short length of contact time. The water flowing into the two lower ponds already contained diquat so that treated water was being replaced by treated water.

It is interesting to note that the regrowth in Pond 1 was quite different from the reinfestation of Ponds 2, 3, and 4 of Chain "A". In Pond 1, the regrowth occurred as tiny plants anchored in the substrate and obviously growing from seeds, roots, or other plant parts which had survived the herbicide under the soil. In Ponds 2, 3, and 4 of Chain "A", the reinfestation occurred primarily as large, free-floating plants which seem almost certain to have washed downstream from above. This distinction between the two sources of reinfestation could be an important one under certain circumstances and it is a factor which has been overlooked too much in the past.

SUMMARY

1. Diquat gave satisfactory control of bladderwort, bur reed, and duckweed for one season in several acid water ponds at rates of 0.17-0.73 ppmw diquat cation.

2. The herbicide treatments had no apparent effect upon largemouth bass fry, pickerel fry, or young yellow perch, and did not affect the spawning of pumpkinseed sunfish.
3. Bottom dwelling invertebrates, (primarily chironomids) maintained their population densities at treatments of up to 0.48 ppmw diquat cation.
4. A concentration of 0.31 ppmw of the cation gave just as effective control of bladderwort as concentrations of 0.53 ppmw and 0.73 ppmw. At the lower concentrations, however, maximum control took longer to achieve and at the lowest concentration, a slight amount of regrowth occurred by late September. (This regrowth could possibly have been due to factors other than original herbicide concentration.)

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ACKNOWLEDGMENT

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APPLYING HERBICIDES BY HELICOPTER

Charles P. Logg, Jr.¹

The helicopter is an ideal and versatile tool for application of herbicides to land or water. The machine can be used from start to finish, in that it can be used to survey the problem, apply the material, and determine the control obtained. Yes, equipped with floats you can even get out and get a grab sample.

Survey work can be accomplished from the helicopter in a very rapid manner. This past spring, for example, the survey of three lakes totalling 1700 acres was accomplished in approximately one hour of flying time.

Before discussing the uses of the helicopter, I would like to compare it with ground equipment and fixed-wing aircraft. Consumers are sometimes reluctant to allow fixed-wing aerial applicators to operate for fear of accidents, but more readily accept the use of the helicopter. This lack of concern about helicopters is related to the machine's maneuverability and unique range of operating airspeeds. These same characteristics make for a high quality of work even in irregular-shaped areas that sometimes are both inaccessible to fixed-wing aircraft and ground equipment. Examples of these areas are irregular shore lines of lakes, i.e. in the control of watermilfoil and marsh areas in control of fragmities.

The versatility of the helicopter allows it to operate close to the treatment area from unprepared landing areas. The variability of the helicopter's airspeed allows wide latitude in application rate. In our experience the rate varied from ten to two hundred and fifty pounds of material per acre. The effect of wind on limiting granular applications is reduced depending, of course, on the size of the pellet and generally operations can be conducted in winds up to 15 knots. As a result the number of working hours is now increased. Even with spray material the helicopter has longer working hours than its fixed-wing cousin and some ground equipment, i.e. mist blowers.

The big selling point for helicopters is economy. The comparative economy on a per hour basis is very high, but because of the helicopter's high productivity it is economical per unit of output and in application time. Turnaround time, since you load

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Vice President, New Jersey Helicopter Airways, Inc.

on the work site, is strictly dependent on speed of loading. The swath width is dependent on the material being applied and/or the application equipment. When applying granular material, swath width is generally determined by particle size and speed of rotation of centrifugal spreaders. Swath speed is determined by desired application rate, obtainable swath width and work rate of the given application equipment. All of these factors (swath width, swath speed, and obtainable work rate) have to be combined to obtain the desired application rate per acre.

Maneuverability of the helicopter far exceeds the airplane. Turn time for the helicopter is only eight seconds compared to thirty or more seconds for a fixed-wing aircraft.

The general limiting factor is the application equipment itself since it determines swath width and work rate. Our spreader gear is ideal for application of 8-16 mesh granules where a 100 foot swath is obtained. For a 24-48 or 30-60 mesh material, swath width of only 40 feet can be obtained. Equipment is being developed which eliminates this disadvantage. Work is also being done to increase the work rate of spray equipment. When the latest equipment available is combined with the helicopter a very efficient application tool results.

The economy of application time is an important factor when a limited time is available for application, the speed of operation determines the number of acres which can be treated in a given season. As an example, this past year we averaged an acre every two minutes of operation when applying one hundred pounds of material per acre.

The actual operational aspects of utilizing a helicopter involve selection of landing area, equipment calibration, flagging, and efficient loading of the hoppers.

The area that a helicopter requires to operate from should be approximately one hundred feet square with clear approaches on two sides. Most everyone has the idea that a helicopter takes off vertically and lands in the same manner. This is not the case, particularly with a heavy load plus the pilot. When operated in this manner the machine is in a critical operating range, therefore clear approaches are needed to and from the loading site to operate in a safe manner. After suitable area is selected, the application equipment should be calibrated for the specific project.

The first thing to accomplish when calibrating the equipment is to determine the swath width which can be obtained. The swath speed is selected which gives the desired application rate which in turn is within the delivery rate of the specific equipment. If the equipment has adequate capacity, the delivery rate has to be adjusted to the desired flying speed. The speed we have used in these cases is 60 miles per hour. This is an easy airspeed to maintain from a pilot's point of view with most helicopters. Once the equipment is calibrated for delivery rate for a specific material it does not change. Calibration can be accomplished by determining the quantity of material delivered in a given amount of time or vice versa. The amount of material delivered in a minute is then divided by the number of acres covered per minute which results in the rate delivered per acre. Small adjustment in the rate is then made mechanically by the flow rate of the equipment or by the airspeed of the helicopter, controlled by the pilot.

After the equipment is calibrated it is still of great assistance to have the area being treated, marked and the specific acreage known. This serves as a double check and insures that the proper amount of material is applied to the infested area.

Excellent results were obtained on all work accomplished. A more professional opinion of the results obtained are attested to by the papers presented by Al Essbach and Roy Younger of the State of New Jersey and Consulting Biologists, Inc., respectively.

In summary, the centrifugal spreader gear, manufactured by Wiggins Airways, Inc., teamed with the versatile helicopter have proved to be an effective killer combination. The productivity of the team can be increased by increasing hopper size and hopper opening. In this manner, larger acreage can be economically covered and the day is coming when aerial applications by the helicopter will overtake its obsolete cousin, the airplane.

WATERMILFOIL CONTROL IN NEW JERSEY LAKES

Alban R. Essbach ^{1/}Introduction:

During the last ten years or so, watermilfoil in New Jersey has become established as the principal noxious species of aquatic vegetation in many of our lakes. The more alkaline water areas of the north and central portions of the state contain particularly dense growths of this vegetation with Myriophyllum spicatum and M. exalbens the dominant species. In the southerly, more acid water areas, Myriophyllum humile and M. verticillatum are the dominant species.

The New Jersey Division of Fish and Game became active in approaching the control problems for watermilfoil and other aquatic plants beginning in 1952 with the establishment of an Aquatic Weed Control Unit. The majority of the operations of this Unit centered around plot evaluations of promising new aquatic herbicides that were being developed. This work resulted in significant contributions toward development of a weed control program in the state.

Treatment Techniques:

As the watermilfoil problem became increasingly acute the first largescale herbicide control operation was undertaken in 1960 on 750 heavily infested acres of 2685 acre Lake Hopatcong. This treatment, using the butoxy ethanol ester of 20% 2,4-D impregnated on 8/15 mesh clay granules ^{2/} was carried out entirely by barges and small boats of the New Jersey Bureau of Navigation. The application rate was 100 lbs. per acre. While an excellent job was achieved in this operation, it was also apparent that considerable funds, man hours and equipment were necessary and the work was spread out over a relatively long period of time amounting to about thirty-four working days.

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^{2/} Manufactured by Amchem Products Inc., Ambler, Pa.

This led to subsequent experimentation with helicopters as a means of applying granular 2,4-D. Initially, agricultural seeding devices capable of holding 150 lbs. of material were attached to the helicopter. These "seeders" use a 12 volt motor to power a spreading disc which is gravity fed and capable of dispersing 2,4-D granules in a 30 to 35 ft. swath. Further refinement, particularly in the last year or two, has produced very good equipment for spreading granular materials and such equipment is installed on the helicopters that we use for our aquatic weed control work. Swath widths of from 75 to 100 ft. are obtainable with these dual hoppers capable of carrying up to 300 lbs. each.

We now feel that the helicopter is the most expedient means of applying granular aquatic herbicides in most of our problem areas. As an example, a helicopter could treat the 750 acres treated by boat in 1960 for \$12,000.00 less than the original cost at today's charter and herbicide prices. There are however, some situations where, because of the physical nature of the shoreline or the presence of many docks, floats, boats or overhanging trees, helicopter effectiveness becomes somewhat limited and boat application is necessary.

Application Results: Lake Hopatcong - Sussex-Morris Counties

The treatment of 750 acres of watermilfoil in Lake Hopatcong during 1960 met with excellent success. Prior to this application, the vegetation had, in effect, severely restricted the recreational use of these areas. Therefore, the dramatic change that was accomplished here initiated great public awareness of what could be done and the state weed control project became firmly established.

Before treatment, a comprehensive survey of the distribution of watermilfoil had been made using echo sounding equipment and Eckman dredges. Vegetation was found in depths up to 14 feet. It should be pointed out that during the winter of 1959-60, Lake Hopatcong was lowered 7 feet in order to attempt control of watermilfoil through freezing of the plants and exposed bottom. This was necessary in order to minimize cost of herbicidal applications which would have been virtually prohibitive if all the infested areas were treated. It is difficult to lower the lake beyond the 7 foot level. Thus, the 750 acres of watermilfoil that were treated with 2,4-D occurred between the 7 and

14 foot contour intervals. The remaining 325 acres of infestation was successfully eliminated through the lowering and freezing technique. It is felt that a certain amount of drift effect of 2,4-D after reflooding was also responsible for eliminating vegetation that persisted in the exposed bottom areas. Following 2,4-D treatment it was noted that within 6 days the tops of plants began to collapse. Within two weeks the stems were defoliated and lying on the bottom. In three weeks time, little trace of the plants could be found.

The end result of the treatment was that no watermilfoil reached noxious proportions until the summer of 1962, two full seasons after application. At that time it was necessary only to spot treat, with helicopter, approximately 35 acres. Most of this regrowth was in the shallower areas that had been primarily controlled in 1960 through exposed bottom freezing. By 1963, three seasons after the first largescale treatment, it became necessary to treat 165 acres of watermilfoil by helicopter. A good portion of this growth occurred within the 7 to 14 foot contour intervals treated initially in 1960.

During 1963, succession of watermilfoil by Potamogeton amplifolius, Anacharis sp. and Vallisneria americana was apparent in many areas. Plans are underway to inaugurate proper herbicide treatment of this vegetation during 1964.

Application Results: Big Swartswood Lake - Sussex County

The first largescale helicopter treatment of watermilfoil undertaken by the state was carried out on this lake in the Spring of 1961. A total of 300 acres of this 494 acre lake was treated with 2,4-D granules at 100 lbs. per acre. Results were very good and re-treatment was not necessary until 1963, two seasons later, when about 60 acres of watermilfoil were effectively controlled. Owing to downstream water rights, no winter drawdown preceded the treatment at Swartswood Lake. The actual helicopter application time involved amounted to about twelve hours or 1½ working days. Equipment on the helicopter consisted of dual hoppers of 300 lb. capacity each feeding to one centrifugal spreader. It has since been determined that the dual hoppers with a spreader on each unit have proved much more effective and able to cut down on application time considerably.^{1/} Three-hundred acres can now be covered in about 6 hours flight time. Proximity to the area being treated and the ability of

the ground loading crew are important factors in expediency of operation.

Application Results: Lake Musconetcong - Sussex-Morris Counties

This lake of 329 acres was treated in its entirety for control of watermilfoil in late May and early June, 1963. The herbicide used was again 2,4-D granules applied at a rate of 100 lbs. per acre. Since this lake has a mean depth of only 5.8 feet, it was decided to treat in two applications of about 150 acres each spaced a week apart in order to reduce chances of possible oxygen depletion. The lake was lowered 10 inches and kept at that level during both applications and for about a week after because of the normally good rate of water exchange.

Results were excellent in this treatment. Not one piece of live watermilfoil was found two weeks later and the lake was once again available for extensive water recreation for the first time in several years. Periodic checks conducted throughout the summer and fall have failed to locate any watermilfoil regrowth.

One other helicopter treatment of watermilfoil was conducted during the 1963 season when 20 acres were successfully controlled in Lake Absegami, Burlington County.

Summary:

Since 1960, 910 acres of watermilfoil have been successfully controlled through use of helicopter distribution of granular 2,4-D. An additional 750 acres were controlled by boat applications, comprising a total of 1,660 acres.

In all treatments granular 2,4-D at the 100 lb. per acre rate was used and the material was applied during late May and early June. Excellent control of watermilfoil has been realized in all areas treated. Regrowth has not attained noxious levels until the second or more generally, the third season following largescale treatment. It is then usually necessary to carry out a relatively minimal amount of maintenance treatment in comparison to the original problem. For example, in one lake where 750 acres were treated in 1960, it was necessary to treat 165 acres of regrowth in 1963.

We feel that the helicopter is now the most expedient means of coping with the majority of noxious aquatic vegetation problems,

although we recognize that in certain situations liquid and granular herbicide applications by boat must be utilized.

As a result of the watermilfoil control program, aquatic recreation, formerly severely restricted, has been maintained at optimum potential. Local real estate and esthetic values degraded by the former weed problem have been restored and the general economy of the lake areas has benefited.

The overall success of the program must be attributed to excellent inter-agency cooperation within the Department of Conservation and Economic Development involving the Division of Fish and Game and the Division of Resource Development, the Bureau of Navigation and the Forests and Parks Section. Credit is also due the many individuals associated with lake Advisory Committees and Protective Associations who were responsible for initiating action to obtain the necessary Legislative appropriations to carry out this program.

With succession problems by other aquatic plants developing in former watermilfoil areas, it is becoming increasingly obvious that aquatic weed control in New Jersey is assuming an almost constant role in the proper maintenance of our heavily utilized lakes and ponds.

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PHRAGMITES CONTROL IN DELAWARE, 1963

Robert A. Beck^{1/} and John H. Steenis^{2/}

Phragmites, often referred to as common reed or feathergrass (Phragmites communis), is an extremely versatile and vigorous plant that grows in flooded, marsh, and terrestrial sites. It is particularly aggressive in dominating hydraulic spoil resulting from ship channel dredging.

The extensive riprap growth of rootstocks of phragmites is often of value in protecting dikes, roads, and marshes from washouts during storms. From a wildlife standpoint it furnishes excellent cover for both hunter and hunted. However, its desirability for ducks, muskrats, and other wildlife is curtailed considerably when this plant completely dominates the areas in which it grows. In industrial and urban locations it can be a serious fire hazard. In areas adjacent to large commercial airfields phragmites can be a hazard because it serves as roosts for birds.

Previous studies on control of this plant indicate that dalapon at 30 lb ae/A, amitrole at 15 lb ai/A, and also the combination of dalapon at 10 lb ae/A with amitrole at 2 lb ai/A, can be used effectively to control this plant in dry sites (Steenis et al., 1959). The effective period for this treatment lasts for about 3 months, extending from the time the plant is 30 inches high until flowering or early fruiting. However, in the case of wet sites, dalapon was not found effective at any rate. Amitrole and amitrole-T were effective at 20 lb ai/A, and a mixture of dalapon at 25-30 lb ae/A with amitrole at 4-5 lb ai/A also yielded successful control during the time when the tassels begin to flower until early fruiting, a period of 2 to 3 weeks. Analyses of operational treatments in Delaware are furnishing additional data on what constitutes a wet and dry site. Also, additional studies with new herbicides are furnishing leads that could be of significance for improving the existing control procedures.

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^{2/} Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland

MATERIALS AND METHODS

To date, over 50 miles of strip treatments have been made on phragmites on an operational basis in Delaware. Much of this work has been done along the Chesapeake and Delaware Canal. Some treatments have been made in the nearby Thousand Acre Marsh. Applications have been put down by plane and from the ground with power spray equipment. A limited amount of work also has been done on a strip basis with a fogging unit. Along the Chesapeake and Delaware Canal, treatments found effective in dry sites were used. For the most part, the dosage rate was dalapon at 15 lb ae/A in combination with amitrole at 2 lb ai/A.

In the studies on evaluation of new herbicides, graded dosages of the following have been used:

amitrole-T (amitrole with ammonium thiocyanate)	10, 12½, 15 lb ai/A
as compared with amitrole	
cacodylic acid	4, 8, 16 lb ai/A
Hercules 7175	4, 8, 16 lb ai/A
dicamba	4, 8, 16 lb ai/A
dichlobenil	4, 8, 16 lb ai/A
isocil	5, 10, 20 lb ai/A
fenac	2, 4, 8, 16 lb ae/A
fenac at 2 lb ae/A in combination with amitrole-T	at 10 lb ai/A
fenac at 2 lb ae/A	" " dalapon " 15 lb ae/A

ANALYSIS OF RESULTS

Evaluation of treatments on phragmites at lower dosage rates of the dalapon-amitrole mixture on sites that were dry on the surface yielded some erratic results. Closer inspection revealed that control was not effective where rootstocks were growing in saturated soil below the surface or where there was free-running water in tiles. The heavier concentration of amitrole at 20 lb ai/A or a mixture of dalapon at 25 lb ae/A with amitrole at 4 lb ai/A would be needed. In the case of regrowth during the same season, probably a lesser dosage rate of the mixture of dalapon and amitrole or amitrole alone would be sufficient. This has yet to be determined.

The series of replicated treatments of amitrole in combination with the ammonium thiocyanate (called amitrole-T) clearly indicates that the latter does complement the amitrole. Whereas amitrole alone at 15 lb ai/A is effective for controlling phragmites in dry sites, excellent results were noted with amitrole-T at rates of 12½ lb ai/A and at 10 lb ai/A. Of the new herbicides, cacodylic acid, Hercules 7175, dicamba, and dichlobenil were not effective at rates of 4, 8, and 16 lb ai/A. Likewise, isocil at 5, 10, and 20 lb ai/A was not effective. Fenac was tried at rates of 2, 4, 8, and 16 lb ae/A without success. However, fenac at 2 lb ae/A in combination with dalapon at 15 lb ae/A yielded good control. Superior control was noted when applying amitrole-T at 10 lb ai/A in combination with fenac at 2 lb ae/A. Further studies are underway to determine to what degree fenac contributes to the effectiveness of amitrole or dalapon.

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1963 Crabgrass Control Results in Pennsylvania

J. M. Duich, B. R. Fleming, A. E. Dudeck and G. J. Shoop¹

The objectives of the 1963 crabgrass trials were to test experimental and commercially available preemergence herbicides in three locations across the state. These tests are of interest due to unfavorable weather conditions which delayed germination by six and ten weeks in two locations and prevented any germination in the third (Pittsburgh) due to a more prolonged drought.

Materials and Methods

The University Park test area was a three year stand of Kentucky 31 fescue maintained at two inches. Crabgrass was seeded in March following thorough aerification.

Philadelphia test was located on a fairway of the Eagle Lodge Golf Club with a natural stand of crabgrass for many years. Turf consisted of Kentucky bluegrass and scattered bentgrass.

Individual test plots were 6' x 10' with three replications. Dry materials were applied by hand following mixing with two gallons of dry soil and emulsions and wettable powders were applied with a four nozzle plot sprayer at 90 gpa with 35 psi.

Philadelphia test was applied on April 10 and 11, two weeks before earliest anticipated crabgrass. Germination was delayed by cold temperatures followed by drought to June 28 and sporadically in July. University Park test was applied on May 10 and germination was noted for a week from July 3. Predominant crabgrass in both locations was D. sanguinalis.

Control ratings were made in September by plant counts in the Philadelphia test and an estimate based on partial count by three individuals in the University Park test. Percent control was based on population of control plots.

Results and Discussion

Crabgrass Control. The following table shows the control obtained at both locations. Philadelphia test averaged 12 percent less control and this was probably due to longer interval between application and initial germination and a more prolonged germination period.

Bandane was included at three rates and four formulations. Three additional forms on varying fertilizer carriers were included at University Park to check reports of increased control. No value from addition of fertilizer could be noted in this test since there was the same range of variability between forms with and without fertilizer. Although there was some variation between formulations the 6488 on cornceb and the T-28-2 wettable

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gave best results in both locations along with the T-28-5 at University Park. The 30, 40 and 60 lb. rates averaged 82, 87, 94 and 60, 82, 90 percent control in the University Park and Philadelphia tests, respectively.

Hercules 9573 gave excellent control either as granular or wettable at 20 lbs. for both locations. The 10 lb. rate was similar at 99 and 100 at University Park but fell off to 81 and 84 percent in Philadelphia.

Similarly excellent results were obtained from Betasan with 98 and 99 percent control at 20 lbs. from both granular and emulsion. The 10 lb. rate fell off slightly in both locations.

The results obtained with the now "older" formulations were generally consistent with previous reports from this and other stations. Dacthal and Zytron gave 95-100 percent control at University Park at recommended rates but averaged 5 percent less in Philadelphia. Double rates were either 99 or 100.

Trifluralin resulted in 93 to 99 percent with either dry or emulsion with the exception of the latter in Philadelphia with only 23 percent control. Results were consistently poor in all replications. Diphenatrilite ranged from 79 to 35 percent and the combination of Trifluralin and Diphenatrilite combination (Greenfield TACK) was excellent at University Park at recommended 10 lbs. at 98 percent, but only 49 in Philadelphia. Doubling the rate resulted in 88 percent control there. These were the two most erratic materials between locations.

Chlordane results were typically fair to poor, 82 to 32 percent, with the exception of the granular which resulted in 96 percent control at University Park. The Pax complex also gave poorer control, 59 to 75, which is typical for low moisture situations.

Calcium arsenate control of 60 and 67 percent in the two locations was lower than usual and believed due to failure of granules to disintegrate without exposure to sufficient moisture. Soil phosphorus level was low, according to soil tests, and should not have been a factor.

Turf Tolerance. The Kentucky 31 fescue at University Park showed no permanent injury from any chemical treatment. A slight temporary discoloration was noted with Zytron emulsion at both rates, Betasan emulsion at 20 and 40, Dacthal wettable at 20 and the chlordane emulsion. These effects disappeared following the second mowing when growth resumed.

Pittsburgh test included the same treatments on one year old Merion bluegrass. Zytron emulsion discolored temporarily, but effects of Betasan emulsion at 40 lbs. were noted for seven weeks with stunted growth and discoloration. No thinning was apparent.

Permanent injury was confined to bentgrass in the Philadelphia test. Zytron and Dacthal severely injured the bent and practically eliminated it at the higher rates. At the lower rates the bent density was reduced by 25 to 40 percent. The Zytron emulsion was the least toxic to bentgrass.

Bent was also slightly thinned by both forms of Trifluralin and the Greenfield TACK. Bluegrass also appeared to be slightly thinned by the granular Trifluralin.

Conclusions

Delay in crabgrass germination by 6 to 10 weeks under dry conditions did not appear to significantly affect chemical control. A longer period prior to and of germination reduced average control by 12 percent in Philadelphia test.

The newest experimental materials, Hercules 9573 and Betasan, gave 98-100 percent crabgrass control at 20 lbs. per acre with nearly similar results at 10 lbs. at one of two locations.

Bandane averaged in excess of 90 percent control at 60 lbs. per acre for various formulations. There were no obvious advantages with formulations containing fertilizer.

Commercial or older formulations performed, in general, as anticipated based on previous trials with minor exceptions. Dacthal and Zytron resulted in good to excellent control, 88 to 100. Chlordane, Diphenatril and arsenicals were poor except for granular chlordane. Trifluralin was also excellent with one exception in straight form and in combination with Diphenatril.

Major turf injury was limited to bentgrass by Dacthal, Trifluralin and Zytron. Kentucky 31 fescue and bluegrass were not injured except for temporary early discoloration by several sprays.

Percent seasonal crabgrass control of two Pennsylvania locations from single spring application of preemergence chemicals. 1963.

Material	Formulation	Rate	% Crabgrass Control	
			Univ. Park	Philadelphia
Bandane 7436	10-A	30 a.i./A	73	55
"	"	40 "	80	78
"	"	60 "	93	85
Bandane 6488	10-CC	30 "	90	68
"	"	40 "	95	87
"	"	60 "	98	96
Bandane 8043	10-V	30 "	78	62
"	"	40 "	85	78
"	"	60 "	95	84
Bandane T-28-2	44.9W	30 "	88	56
"	"	40 "	86	87
"	"	60 "	99	96
Bandane T-28-3	3-F	30 "	80	---
"	"	40 "	84	---
Bandane T-28-4	6.1F	30 "	90	---
"	"	40 "	93	---
Bandane T-28-5	9.4F	30 "	96	---
"	"	40 "	98	---
Hercules 9573	80W	10 "	100	81
"	"	20 "	100	100
Hercules 9573	5-G	10 "	99	84
"	"	20 "	100	100
Betasan	4 EC	10 "	94	87
"	"	20 "	98	99
"	"	40 "	99	100
Betasan	5-G	10 "	96	---
"	"	20 "	99	---
"	"	40 "	100	---
Chlordane	8.26 EG	90 "	53	45
Chlordane	5-G	90 "	96	83
Chlordane (Halts)	23	6/M	67	32
Ca. Arsenate	73 G	14/M	60	67
Pax	-----	20/M	75	59
Diphenatril	11.5-V	30 a.i./A	79	35
Trifluralin	2-V	1.5 "	99	99
Trifluralin	0.75 EC	2 "	93	23
Zytron (Dow CGK)	3 EC	16 "	95	88
"	"	32 "	99	---
Zytron (Dow CGK)	4.4	16 "	99	93
"	"	32 "	100	100
Dacthal (Vito-Grow)	2.53	11 "	100	91
"	"	22 "	100	100
Dacthal	75-W	10 "	99	100
"	"	20 "	100	100

POSTEMERGENCE CRABGRASS CONTROL RESULTS FOR 1962 AND 1963¹J. A. Jagschitz and C. R. Skogley²

Probably no other weed has gained such notoriety in turfgrass areas as has crabgrass (*Digitaria sanguinalis*) and (*Digitaria ischaemum*). Although preemergence chemical control of crabgrass is very effective there are many times when postemergence chemical control is necessary.

Two tests were initiated, one in 1962 and the other in 1963, to evaluate new and presently used chemicals for the selective postemergence control of crabgrass in lawn type turf. Various formulations, rates, chemical combinations and number of applications were studied.

Materials and Methods

Test I (1962)

This test was initiated on lawn turf on the campus of the University of Rhode Island. The turf was composed of Colonial bentgrass, Kentucky bluegrass and creeping red fescue. The area was mowed weekly at a height of one inch during the test and watered when necessary. Mowing and watering was not done for at least three days after any chemical application.

Chemicals were applied on July 12 and 13. Certain of the plots treated on July 12 received a second application on July 19 and some were treated for a third time on July 27. The crabgrass on July 12 was in the two and three leaf stage and the turfgrasses were growing well.

Rainfall in the amount of 0.17 inches fell immediately after the July 12 application and 0.14 inches were recorded on July 21 - two days after the second treatment. Maximum temperatures between July 12 and August 7 did not exceed 83°F and averaged about 77°F.

Seventy-six chemical treatments and four check plots were completely randomized in each of three blocks. Individual plot size was 4 x 6 feet. The chemicals, formulations, rates and number of applications are shown in Table I. Additional information for these chemicals is as follows: A-12 and A-12-M were 1962 formulations of monoammonium methanearsonate, "Ansar" 157 and K = 0.5% Ultrawet K (Ansul); AMA was 8% dodecyl and 8% octyl ammonium methylarsonate (Vineland); CPA was calcium propyl arsonate and CMA was calcium methyl arsonate (Vineland); Calar was calcium methylarsonate (Vineland); DMA was disodium methylarsonate: 100% WSP, "Ansar" 184 (Ansul), 50% WSP (Niagara), 31.5% WSP, Crab-E-Rad (Vineland), 3.15% granular, Void (International Minerals), 2.65% granular, Crabkill (Patco), and 2% vermiculite, "Ansar" 184 (Ansul); Dicryl was 3'4'-dichloro-2-methylacrylanilide, EC (Niagara); SD 7961 was 2,6-dichloro-1,4-benzamide, WP (Shell); 12161-A and 12161-B were unknown (Chipman); CPA + Dacthal was calcium propyl arsonate + dimethyl 2,3,5,6-tetrachloroterephthalide formulated together (Ortho);

¹Contribution No. 1106, R.I. Agricultural Experiment Station, Kingston, R.I.

DMA + 2,4-D + 2,4,5-T + trifluralin was disodium methylarsonate + iso-octyl ester of 2,4-dichlorophenoxyacetic acid and of 2,4,5-trichlorophenoxyacetic acid (% in table is ae) + a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (Eli Lilly).

Dry formulations were applied by hand. Sprays were applied in water at 227 gpa (CPA + CMA slurry at 906 gpa) using a pressure regulated hand sprayer. All dry formulations were applied to moist turf except those applied on July 13 and CPA + CMA, 12161-A and 12161-B applied on July 12. SD 7961 was watered in after application at the rate of 208 gal/1000 sq ft.

Visual turf injury estimates were made on July 18, 25, August 1, 9 and 31. The scale used was 0-5 with 0 being none and 5 being complete kill. Visual crabgrass cover estimates were made on August 31 for all plots. Percent control was based on the reduction when compared to the average cover of the check plots.

Test II (1963)

This test was located at the turfgrass research area at the University of Rhode Island. The turf was an old established stand of Kentucky bluegrass and Colonial bentgrass. The area had been scarified and overseeded with crabgrass in late April. Crabgrass germination was evident by late June. At the time of the first chemical application the crabgrass was tillering and covered about half of each plot. During the test the area was mowed to a height of 3/4 inch.

Chemical treatments were first applied on August 1. Those receiving a second or third application were treated on August 7 and August 15. Rainfall measured 2.55 inches on July 30, 2 days before the test began, and on August 4 0.31 inches, August 12-14 1.48 inches and 0.89 inches August 18-20. Maximum temperatures in August did not exceed 83°F and averaged about 78°F.

Nine chemical treatments and one check plot were completely randomized in each of two blocks. Individual plot size was 4 x 6 feet. The chemicals, formulations, rates and number of applications are shown in Table II. Additional information for these chemicals is as follows: DMA was disodium methylarsonate 100% WSP, "Ansar" 184 (Ansul); monoammonium methanearsonate 20% solution, "Ansar" 157 (Ansul); monosodium acid methanearsonate 50.6%, 6.6#/gal, "Ansar" 170 (Ansul); triethanolamine methanearsonate 15.8% + 2,4-D as the triethanolamine salt of 2,4-dichlorophenoxyacetic acid 5.75%, net wt 8.84#/gal, "Ansar" 290D (Ansul); calcium acid methylarsonate 10.3%, .927# ai/gal, Calar (Vineland); ammonium methylarsonate 8% dodecyl and 8% octyl, 1.45# ai/gal, AMA (Vineland); DMA + 2,4-D + 2,4,5-T + trifluralin was a formulation of disodium methylarsonate 4% + iso-octyl ester of 2,4-dichlorophenoxyacetic acid .95% ae and of 2,4,5-trichlorophenoxyacetic acid .47% ae + a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine .57%, granular, Summertime Crabgrass Killer (Eli Lilly); DMA + 2,4-D was a formulation of disodium methylarsonate 3% + dimethylamine salt of 2,4-dichlorophenoxyacetic acid 1.25% ae, granular, Summer Crabgrass Killer (Heritage House); and CPA + CMA was calcium propyl arsonate 18% + calcium methyl arsonate 6%, granular (Vineland).

Dry formulations were applied by hand to moist turf. Sprays were applied in water at 227 gpa using a pressure regulated hand sprayer. Visual turf injury estimates were made on August 7, 12, 20 and September 3 using the scale of 0-5 as in Test I. Crabgrass control estimates were made on August 20 and September

Results and Discussion

In addition to chemicals, formulations, rates and number of applications, Table I also contains ratings of turfgrass injury and crabgrass control percentages resulting from the 1962 trial.

A single application of CPA + CMA in vermiculite formulations gave 96% control of crabgrass with negligible turf injury. The same rate in a slurry formulation gave less control with increased injury. DMA 50% WSP at 5 lbs produced 85% control with slight injury. Control was 94% with DMA + Dicryl (2.8 + 1 lb) and 82% with DMA + 2,4-D + 2,4,5-T and trifluralin but injury was moderate. Dicryl added to DMA increased the control of crabgrass but also increased the injury. A-12-M at 2 lbs and DMA at 5 lbs, both in liquid formulations, gave significantly better control than comparable dry formulations and also a slight increase in injury.

With a single application all other chemicals controlled less than 75 percent of the crabgrass present in the plots. SD 7961 and I2161-A and B showed very little herbicidal activity at the rates included.

Good crabgrass control with slight injury was obtained with two applications of A-12 liquid formulation at 2 lbs (90%) and DMA 50% WSP at 3 or 4 lbs (98%). Other chemicals at certain rates such as A-12-M liquid, A-12-M + Dicryl, DMA + Dicryl, Calar and AMA had control over 94% but injury was moderate. In most cases the turf recovered as indicated by ratings on August 31.

The addition of Dicryl to A-12-M increased crabgrass control significantly from 44 to 96% at the 1 lb rate and from 66 to 99% at the 2 lb rate, but turf injury was also increased. Dicryl added to DMA only increased turf injury since crabgrass control at the 3 lb rate of DMA used for comparison was 99%.

Dry formulations of A-12-M at the comparable rate of 2 lbs produced significantly less crabgrass control than the liquid formulation while turf injury was negligible. Other formulation differences were noted. The 50% and 100% WSP formulations of DMA did not cause as much injury as did the 31.5% formulation at the comparable rate of 5 lbs while control was similar. The three WSP DMA formulations produced better control than the three dry formulations but also more injury. The 2.65% dry formulation of DMA had significantly better control (80%) than was produced with the 3.15% formulation (33%) or the 2% formulation (44%). At the recommended label rate of each control was similar (42 to 50%).

When three applications of chemicals were applied control generally increased but turf injury did also particularly with the higher rates of the liquid formulations. Control 90% or better was obtained with three applications of the following: A-12 at 2 lbs (at 1 lb 84%), A-12-M at 1 and 2 lbs, A-12-M 2% Vermiculite K at 3 lbs (cobs 84%) (Verm 63%), DMA 50% WSP at 3 lbs and DMA 2% Verm at 5 lbs. It is of interest that at only 1 lb per acre three applications of A-12 in liquid form controlled 84 percent of the crabgrass without injuring the turf. A-12-M in similar form and rate gave 98 percent control without turf injury. The dry formulations of DMA and A-12-M showed improved performance at three applications but, in general, did not match the degree of control obtained with the liquid formulations.

twice or three times. Three applications were made only when it appeared that control would not be complete with two treatments. At the rates used crabgrass control in excess of 89 percent was obtained with DMA, monoammonium methanearsonate, monosodium methanearsonate, triethanolamine methanearsonate + 2,4-D, calcium acid methylarsonate, ammonium methylarsonate and DMA + 2,4-D + 2,4,5-T + trifluralin. The latter three caused greater turf injury. DMA + 2,4-D and CPA + CMA gave less than 81% control of crabgrass.

Late season injury was moderate to severe with DMA + 2,4-D, DMA + 2,4-D + 2,4,5-T + trifluralin and with the CPA + CMA treatment. Although turf discoloration followed the application of all materials during the course of the test recovery was nearly complete by early September for all of the chemicals except the three noted.

Conclusions

In the continuing search for more effective and safer chemicals two post-emergence crabgrass control tests were carried out during the summers of 1962 and 1963. Based on the results obtained in these two tests the following conclusions were reached:

1. Good crabgrass control was obtained with a single application of vermiculite formulations of CPA + CMA at the 65 lb per acre rate on crabgrass in the 2-3 leaf stage. Control was not as good on more mature crabgrass. Turf injury varied from negligible to moderate.
2. Two applications of DMA WSP at 3 or 4 lbs per acre, A-12 and monoammonium methanearsonate at 2 lbs, monosodium acid methanearsonate at 2.2 lbs, triethanolamine methanearsonate + 2,4-D at 2.4 + .5 lbs gave good crabgrass control with some turf injury. Other chemicals such as calcium acid methylarsonate, ammonium methylarsonate, dicryl + DMA and dicryl + A-12-M also gave good crabgrass control but turf injury was greater.
3. Three applications of A-12 at 2 lbs, A-12-M at 1 lb, DMA WSP at 3 lbs and DMA vermiculite at 5 lbs gave good crabgrass control with some turf injury.
4. Dicryl added to A-12-M or DMA sprays increased the degree of crabgrass control but also increased turf injury.
5. At comparable rates of DMA or A-12-M, liquid applications were more active than dry applications. Some dry formulations of DMA gave better crabgrass control than others at comparable rates with little difference in turf injury. At comparable rates some WSP formulations of DMA caused more turf injury than others while control was similar.
6. Combinations of DMA and other materials such as 2,4-D, 2,4,5-T or trifluralin may cause injury to the turf above that normally obtained with the DMA alone.

Table I. Postemergence crabgrass control and turf injury in lawn turf using various chemical applications. R.I. Agricultural Experiment Station, 1962.

Chemical	ai and formulation	# ai/A per application	Turf injury (0-5)					Percent crabgrass control
			7/18	7/25	8/1	8/9	8/31	8/31
<u>ONE APPLICATION (7/12)</u>								
CPA+CMA	18%+6% Verm.	32.5	.1	.1	.1	-	-	79
" "	"	65.0	.1	.2	.2	.3	.2	96
" "	12% Verm.	32.5	.1	.2	.1	.1	-	74
" "	"	65.0	.1	.2	.1	.2	.2	97
" "	2.5#/gal Slurry	43.3	-	-	-	-	-	56
" "	"	65.0	.8	.5	.8	.5	.2	85
CPA+Dacthal	13.75%+2.75% Gran.	30+6	-	-	.1	.4	.6	64
SD-7961	50% WP	.25	-	-	-	-	-	7
"	"	.5	-	.1	-	-	-	0
12161-A	5% Gran.	10	-	-	-	-	-	9
"	"	20	-	-	-	-	-	16
"	"	40	.1	-	-	-	-	9
12161-B	5% Gran.	10	-	-	-	-	-	25
"	"	20	-	-	-	-	-	6
"	"	40	.1	-	-	-	-	4
<u>ONE APPLICATION (7/13)</u>								
A-12	20% Liq.	2	.1	-	-	-	-	70
A-12-M	20% Liq.	2	.2	-	.1	.2	-	60
A-12-M	2% Verm.	2	-	-	-	-	-	18
A-12-M	2% Verm. K	2	-	-	-	-	-	13
DMA	2% Verm.	5	-	-	-	-	-	47
DMA	50% WSP	5	.4	-	-	-	-	85
DMA+Dicryl	50% WSP+1.6#/gal	2.8+1	.4	1.0	.6	.3	-	94
DMA+2,4-D+2,4,5-T + trifluralin	4.54%+1.16%+.39% +1.54% Liq.	3.5+.56+.19 +.75	.4	.2	.5	1.1	.3	82

Table I (Cont'd.)

Chemical	ai and formulation	# ai/A per application	Turf injury (0-5)					Percent crabgrass control
			7/18	7/25	8/1	8/9	8/31	8/31
<u>TWO APPLICATIONS (7/12 & 19)</u>								
A-12	20% Liq.	1	-	-	.2	-	.1	65
"	"	2	-	-	-	-	-	90
"	"	4	.1	.7	.4	.2	.1	93
A-12-M	20% Liq.	1	-	-	.2	-	-	44
"	"	2	.1	.1	.1	.1	-	66
"	"	4	-	1.5	1.0	.7	.2	99
A-12-M+Dicryl	20% Liq.+1.6#/gal	1+1	-	1.0	.5	.1	.1	96
"	"	2+1	.1	1.3	.6	.2	-	99
A-12-M	2% Verm.	2	-	-	-	-	-	33
"	"	3	-	-	-	-	-	42
A-12-M	2% Verm. K	2	-	-	-	-	-	24
"	"	3	-	.1	-	-	-	38
A-12-M	1% Cobs	2	-	-	-	-	-	13
"	"	3	-	-	-	-	-	27
DMA	50% WSP	3	.1	.1	.1	.2	.2	99
"	"	4	.1	.1	-	.2	-	98
"	"	5	.2	.8	.4	.3	.1	97
"	"	6	.3	1.3	.8	.9	.5	97
DMA+Dicryl	50% WSP+1.6#/gal	3+1	.1	2.0	.9	.3	.1	97
"	"	4+1	-	2.5	1.8	1.2	.6	97
DMA	31.5% WSP	5	.2	1.3	1.2	1.1	.7	99
"	"	6.86	.1	2.3	1.5	1.5	.8	98
DMA	100% WSP	5	.1	.6	.3	.1	-	97
DMA+2,4-D+2,4,5-T + trifluralin	4.54%+1.16%+.39% +1.54% Liq.	3.5+.56+.19 +.75	-	.6	1.0	1.5	1.0	61
DMA	2% Verm.	2	-	-	-	-	-	7
"	"	3	-	-	.1	-	-	20
"	"	5	-	-	-	-	-	44
DMA	3.15% Gran.	5	-	-	-	-	-	33
"	"	5.9	-	-	-	-	-	50

Table I (Cont'd.)

Chemical	ai and formulation	# ai/A per application	Turf injury (0-5)					Percent crabgrass control 8/31
			7/18	7/25	8/1	8/9	8/31	
DMA	2.65% Gran.	4.16	.1	-	-	-	-	42
"	"	5	.1	-	-	-	-	80
DMA+2,4-D+2,4,5-T + trifluralin	4%+.95%+.47% +.57% Gran.	3.5+.8+.4 +.5	.1	.2	.2	.3	.1	54
Calar	.927 #/gal	5	-	2.2	1.3	.6	.3	95
AMA	1.45 #/gal	8	-	2.7	2.2	1.4	.9	95
<u>THREE APPLICATIONS (7/12 & 19 & 27)</u>								
A-12	20% Liq.	1	-	-	-	-	-	84
"	"	2	.1	.1	.3	.5	-	97
"	"	4	-	.8	2.0	2.5	1.5	97
A-12-M	20% Liq.	1	-	-	-	-	-	98
"	"	2	-	-	.4	.8	.3	98
"	"	4	.1	1.2	2.2	2.5	1.5	98
A-12-M	2% Verm.	2	-	-	-	-	-	56
"	"	3	-	-	-	.1	-	63
A-12-M	2% Verm. K	2	-	-	-	-	-	77
"	"	3	-	-	-	.1	.1	98
A-12-M	1% Cobs	2	-	-	-	-	-	34
"	"	3	-	-	.2	.2	-	84
DMA	50% WSP	3	.2	.1	.4	.8	.7	98
"	"	4	.1	.3	.9	1.0	.4	98
"	"	5	.3	1.1	1.2	2.0	1.3	98
"	"	6	.1	1.2	1.8	2.3	1.7	97
DMA	2% Verm.	2	-	-	.2	-	-	61
"	"	3	-	-	-	-	-	79
"	"	5	-	-	.2	-	-	90
Checks (4)	-	-	-	-	-	-	-	-
LSD								25
5%								33
1%								
Average percent crabgrass of check plots								75

Table II. Percent crabgrass control and turf injury in lawn turf from postemergence applications of various chemicals. R.I. Agricultural Experiment Station. 1963.

Chemical	Formu- lation	# ai/A per application	No. of appl†	Turf injury (0-5)				Percent crabgrass control	
				8/7	8/12	8/20	9/3	8/20	9/3
DMA	WSP	4	2	.1	1.1	.5	.3	98	95
monoammonium methanearsonate	liq.	2	2	.1	1.0	.5	.6	96	94
monosodium acid methanearsonate	liq.	2.2	2	0	.8	.2	.3	96	92
triethanolamine methanearsonate+2,4-D	liq.	2.4+.5	2	0	.9	.6	.4	96	89
calcium acid methylarsonate	liq.	2.5	2	.4	2.0	.4	.6	98	97
ammonium methylarsonate	liq.	4	2	.8	2.0	.8	.5	99	98
DMA+2,4-D+2,4,5-T+trifluralin	gran.	3.5+.8+.4+.5	3	0	.4	1.1	2.8	81	95
DMA+2,4-D	gran.	3.3+1.4	3	0	0	.1	1.4	72	76
CPA+CMA	gran.	65	1	1.9	3.0	2.5	1.0	90	81
check	--	--	-	0	0	0	0	--	--
								LSD	5
								5%	8
								1%	
Average percent cover in check plots								80	81
†number of applications, 1st 8/1, 2nd 8/7 and 3rd 8/15									

TOLERANCE OF ESTABLISHED LAWN GRASSES, PUTTING GREENS,
AND TURFGRASS SEEDS TO PRE-EMERGENCE CRABGRASS CONTROL CHEMICALS

J. F. Cornman, F. M. Madden, and N. J. Smith¹

Extensive areas of established turf were devoted to trials with old and new chemicals for pre-emergence crabgrass control during the 1963 season. The stand of crabgrass in these areas was inadequate to permit any reportable observations on the effectiveness of these various materials used in this manner. A number of unreplicated collateral trials with some chemicals did yield information of potential interest.

Effects of R-4461² and H-9573³ on established turfgrasses

In anticipation of future needs for stands of perennial lawn grasses for tolerance tests, areas were planted in 1961 with pure seedings of Merion Kentucky bluegrass, commercial Kentucky bluegrass, Pennlawn red fescue and creeping bent and maintained at $1\frac{1}{4}$ inches. On May 9, 1963 R-4461 and H-9573 were applied to 4 x 4 foot plots of each of these grasses at rates increasing from below those considered effective for crabgrass control to a high of several times the assumed effective rate. Thus R-4461 (5% granular) was applied at rates of 10, 20, 30, 40, 60, and 80 lb. ai/A. The H-9573 (5% granular) was applied at rates of 10, 15, 20, 30, 40, and 60 lb. ai/A. Since DAC 893⁴ and DMPA⁵ had both produced injury under some circumstances, each of these was applied at 1, 2 and 3 times the usual crabgrass control rate to serve as a comparison with the newer materials.

Observations throughout the growing season revealed that H-9573 did not injure any of the four major turfgrasses at any of the rates used. R-4461 did not injure or discolor either of the Kentucky bluegrasses or the bentgrass at any of the rates used. The 80 lb./A rate of R-4461 did somewhat discolor the Pennlawn red fescue but this discoloration disappeared after several mowings. R-4461 at rates of 60 lb. ai/A and below caused no discoloration of the fescue.

Thus, with the exception of the single plot of red fescue, none of the R-4461 or H-9573 treatments discolored any of the four turfgrasses. With both materials the plots of red fescue and the two bluegrasses were a bit darkened in color in contrast to adjacent untreated turf. This darker green color increased slightly with increasing dosages beginning above the 20 lb. rate of R-4461 and above the 15 lb. rate of H-9573. At its most extreme this darker green color was equivalent to a light application of fertilizer. A stimulation of the existing turf or a slight temporary thinning and subsequent regrowth are two possible explanations for this effect.

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Turf responses to DAC 893 at the usual crabgrass control rate (12 lb. ai/A) were in predictable order. The two bluegrasses seemed unaffected in any way, bentgrass was thinned about 30%, and almost all of the red fescue was removed. The 2X and 3X rates of DAC 893 did not injure common Kentucky bluegrass but by mid-September had thinned the Merion Kentucky bluegrass about 30%. These heavier rates of DAC 893 severely injured bentgrass but recovery of the bentgrass plus an apparent increase in annual bluegrass provided a nearly complete cover of turf on these plots by mid-September. The heavier rates of DAC 893 destroyed most of the red fescue.

Turf injuries with DMPA at the usual crabgrass control dosage (15 lb. ai/A) and at two or three times that rate were similar to those with DAC 893 but somewhat intensified. All three rates of DMPA removed almost all of the red fescue. Bentgrass was severely injured with all three rates of DMPA but there was much bent recovery and an apparent increase in annual bluegrass, so that all three plots were fairly well covered with turf by mid-September. On Merion Kentucky bluegrass the 1X rate of DMPA caused no apparent damage but the 2X and 3X rates thinned the Merion about 30%.

Unexpected effects with DMPA were apparent on the plots of commercial Kentucky bluegrass. The 1X rate thinned the Kentucky bluegrass lightly (say 5%) and the 2X and 3X rates reduced the bluegrass population by about 30%. An outstanding fungicidal effect of the DMPA became evident within a few weeks after the applications were made. At the time of chemical treatments the stand of Kentucky bluegrass was good over the entire area. Soon thereafter Helminthosporium leafspot invaded the commercial Kentucky bluegrass very severely. The DMPA treated plots stood out conspicuously during the entire period of this attack as bright green islands with little or no gross effects from the disease. By the end of the growing season the damaged turf had recovered enough so that this fungicidal effect was not nearly so conspicuous.

In summary, it appears that the common turfgrasses at lawn height tolerate a wide range of dosages of R-4461 or H-9573. DMPA may have an important fungicidal effect so far as Helminthosporium leafspot is concerned.

Injury to putting green turf from pre-emergence crabgrass control chemicals

The success of several chemicals in the pre-emergence control of crabgrass in lawn turf suggests a possible application to putting green turf, where crabgrass and annual bluegrass are serious pests. The injury or discoloration of putting greens is much more critical than with lawn-type turf, so the tolerance of putting green grasses to pre-emergence chemicals is of primary importance. This report enumerates the degrees of injury caused by various chemicals applied to an old but well-maintained putting green of creeping bentgrass and annual bluegrass. Chemical applications were made on April 25, 1963 at the Nassau County Park on 3 X 3 foot unreplicated plots. The entire treated area was watered thoroughly immediately after the applications were made.

DAC 893 at 12 lb. ai/A produced no discoloration until about the end of the second month. Then the turfgrasses gradually became browned and weakened until by mid-October they were badly thinned and in too poor condition to be practical for putting green purposes.

DMPA at 15 lb. ai/A produced no immediate discoloration. Injury began showing in about five weeks, increased gradually at a somewhat slower rate than with DAC 893 but by mid-October the turf was just as badly thinned.

Calcium arsenate at 10 lb. ai/A produced turf discoloration within a week. This browning of the turf lasted about six weeks and gradually disappeared. In this instance the turf injury was probably attributable to the particular formulation of calcium arsenate used, for the same formulation produced much more injury to standard lawn grasses than did other formulations of calcium arsenate.

H-9573 at 10 and 15 lb. ai/A produced no discoloration for some time but these plots slightly brown and off-color during June from the late April treatment. The turf then recovered. H-9573 at 30 lb. ai/A produced browning that was evident in both May and June.

R-4461 emulsion at 15 and 20 lb. ai/A and R-4461 granular at 15, 20 and 30 lb. ai/A produced no visible injury at any time. Of the five materials reported here, R-4461 was the only one that did not produce visible injury to the putting green turf.

Crabgrass control, chemicals vs. seed

Any new chemical for pre-emergence crabgrass control is judged first on its effectiveness for crabgrass control and its effects on established grass. A less immediate but practical question involves possible delays necessary if successful seedings of desirable grasses are to be made in a treated turf. This report concerns trials made with three of the newer chemicals for which data about their effects on newly planted seed are inadequate.

Bandane⁶ (10% granular), R-4461 (5% granular) and H-9573 (5% granular) at crabgrass control rates (25, 20 and 15 lb. ai/A respectively) were spread in parallel 3 foot wide strips on a newly prepared seed bed at time intervals so arranged that when a later seeding was made the chemicals had been on the surface of the soil for 6, 2 and 1 week and 0 days prior to seeding. Immediately after spreading, each chemical was lightly raked into the surface soil to minimize flotation from rain and irrigation. On August 2, 1963, perpendicular strips 3 feet wide across the chemically treated strips were planted with Merion Kentucky bluegrass, Pennlawn red fescue, seaside bentgrass, and perennial ryegrass. On September 20, seven weeks after seeding, the relative seedling stands were recorded as shown in Table 1. The percentage figures are visual estimates, at 10% intervals, with 100% representing the excellent stand in the untreated strips and 0 representing completely bare ground.

Table 1. Seed establishment after seedbed treatments with various chemicals.

Chemical rate	Weeks delay before seeding	Percent stand 7 weeks after seeding			
		ryegrass	bentgrass	red fescue	Merion Kentucky bluegrass
Bandane	0	100	100	100	100
35 lb. ai/A	1	100	100	70	70
	2	100	100	60	70
	6	100	100	80	80
	0	80	70	20	10
R-4461 20 lb. ai/A	1	60	50	10	0
	2	60	70	10	0
	6	60	90	20	0
	0	60	10	0	0
H-9573 15 lb. ai/A	1	50	0	0	0
	2	20	0	0	0
	6	20	0	0	0

Seeding date - August 2, 1963

Chemical treatments - August 2, 1963 and 1, 2 and 6 weeks prior thereto

In plots rated 80% or less in Table 1 the stand of seedlings was deemed sufficiently thinned to have been obvious to an experienced viewer, even without untreated areas for comparison, had a large area received the particular treatment.

The data in Table 1 suggest several generalizations. At the rates of chemicals used, perennial ryegrass and bentgrass were less affected than were the slower-germinating red fescue and Kentucky bluegrass. The injurious effect of bandane to Merion Kentucky bluegrass and red fescue seed occurred and increased as seedings were delayed after chemical treatment. The poor seedling stands, regardless of the delay involved, seem to rule out the subsequent planting of desirable grasses during the same portion of the growing season as R-4461 or H-9573 might be applied.

2. R-4461 = N-Beta (-o,c-diisopropyl dithiophosphoryl ethyl) benzene sulfonamide; Stauffer Chemical Co. "Betasan."
3. H-9573 = 2,6-di-tert-butyl-p-tolyl methylcarbamate; Hercules Powder Co.
4. DAC 893 (DCPA) = 2,3,5,6-tetrachloroterephthalic acid; Diamond Alkali Co. "Dacthal."
5. DMPA = O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate; Dow Chemical Co. "Zytron."
6. Bandane = polychlorodicyclopentadiene isomers; Velsicol Chemical Co.

THE EFFECT OF VARIOUS PREEMERGENCE CRABGRASS HERBICIDES
ON TURFGRASS SEED AND SEEDLINGS¹

C. R. Skogley and J. A. Jagschitz²

Several studies during the past few years (1,2,3,4,5) have clearly indicated that most preemergence crabgrass herbicides cannot be safely applied at the time of turfgrass seeding or shortly after emergence. It would be highly desirable if crabgrass preventers could be used during these periods. As new herbicides are released with a crabgrass control potential, it appears desirable to determine their effect on grass seed and seedlings in the search for a material to fulfill this need.

Two trials were carried out in 1962 and two in 1963 in which certain herbicides were applied to the soil at intervals prior to turfgrass seeding or to young turf at various times after seeding. All trials were located at the turfgrass research area of the Agricultural Experiment Station. The soil in this location is Bridgehampton silt loam.

Test No. 1, 1962

Materials and Methods

The first study involved the use of Bandane (Polychlorodicyclopentadiene isomers) on young, pure stands of Kentucky bluegrass (*Poa pratensis*), Colonial bentgrass (*Agrostis tenuis*) and creeping red fescue (*Festuca rubra*).

The grasses were seeded on April 26, 1962. A 10-20-10 grade of fertilizer at the rate of 10 lb per 1000 square feet was worked into the soil during seed-bed preparation. Common Kentucky bluegrass was seeded at the rate of 3 lb per 1000 sq ft, Astoria Colonial bentgrass at 1 lb and Illahee creeping red fescue at 5 lb per 1000 sq ft. The bluegrass seed germinated poorly and was reseeded on May 25.

The experimental design employed was a split-plot (grasses split) with four blocks. The three grasses were randomly seeded in each block in strips 4 by 15 feet in size. Four chemical treatments and one check plot were randomized within each grass strip. Plot size was 4 by 3 feet.

The bentgrass and fescue strips were mowed for the first time on June 4 and the chemical treatments were made on June 6. The bluegrass was mowed initially on July 13 and chemical treatment was made the same day. Maximum air temperatures on either treatment date did not exceed 83°F and did not go above this level for at least a week following treatment.

Dry herbicide formulations were applied by hand and the liquid was applied with a hand sprayer at 30 psi using 272 gallons of water per acre.

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Results and Discussion

Turfgrass injury readings were made 5 days, 3 weeks and 6 weeks after the date of chemical treatment. This data is presented in Table 1.

Table 1. Turfgrass injury to Colonial bentgrass, creeping red fescue and Kentucky bluegrass when two formulations and rates of Bandane were applied within two days of the first cutting.

Chemical and formulation	# ai/A	Turf injury days after treatment*								
		5 days			21 days			42 days		
		Bent	Fescue	Blue	Bent	Fescue	Blue	Bent	Fescue	Blue
Bandane (Verm)	30	0.0	0.0	0.4	0.1	0.1	0.0	0.7	1.6	0.1
" "	60	0.2	0.0	0.6	0.3	0.2	0.0	1.8	2.8	0.5
Bandane (EC)	30	1.0	0.6	1.4	2.5	2.3	0.8	3.1	3.8	0.4
" "	60	3.0	2.8	3.0	4.0	4.1	4.0	4.6	4.6	3.6
None	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
								LSD 5%	0.6	0.6
								1%	0.8	0.9

*Turf injury = 0 - none, 5 - complete kill.

Turfgrass injury may not appear for some weeks after the application of Bandane to seedling turf. As indicated by the injury ratings in Table 1 the vermiculture formulations showed very little turf injury to any of the grasses for the first three weeks. At the end of six weeks, however, the red fescue showed marked injury with both rates of the chemical and the bentgrass was injured where the 60 lb rate had been applied.

Where the emulsifiable concentrate was used injury was considerably more severe than with the dry form at both rates and on all three grasses.

Bluegrass was the most tolerant of Bandane treatment. It showed lasting injury only with the 60 lb rate of the liquid form. Fescue was the least tolerant of the three grasses to chemical treatment. Six weeks after treatment it showed moderate to severe thinning and retardation at both rates of both formulations. The bentgrass was not seriously injured with the light rate of the dry form but was moderately to severely injured by all other treatments.

Test No. 2, 1962

Materials and Methods

This study was designed to check the effect of Diphenatril (Diphenylacetoneitrile) and Trifluralin (a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) on seed germination and turfgrass establishment. The experimental design was a split-plot (chemicals split) with 4 blocks. Three chemicals and a check treatment were randomized in strips 4 by 12 feet in size in each block. Three by four foot plots were seeded randomly within each strip on four dates following chemical application.

The seedbed was prepared on April 25 and the chemicals, all dry formulations, were applied by hand on the following day. Plots were seeded at intervals of 2, 4, 6 and 8 weeks after chemical application. The seed mixture consisted of creeping red fescue, 47.5%; Kentucky bluegrass, 47.5% (1/2 common and 1/2 Merion); and Colonial bentgrass 5% and was sown at the rate of 3 lb/1000 sq ft.

At the time of seeding the seedbed was loosened to a depth of 1 inch with an iron rake. Following seeding the plots were raked lightly, rolled and watered. During the course of the study the plots were irrigated to insure adequate soil moisture.

Results and Discussion

Estimates of percent stand were made about 3, 6 and 9 weeks after each seeding. The estimates made at intervals of 3 and 9 weeks after each seeding are shown in Tables 2 and 3 respectively.

Table 2. Estimated percent stand of mixed turfgrass about 3 weeks after seeding on seedbeds treated with Diphenatrilc and Trifluralin.

Chemical treatment	Time of seeding after seedbed treatment			
	2 wks	4 wks	6 wks	8 wks
	Percent stand*			
Diphenatrilc - Verm 30# ai/A	53	76	83	95
Trifluralin - Verm 1# ai/A	9	25	73	70
" " 1 1/2# ai/A	8	33	38	35
None	100	100	100	99
LSD treatment x time of seeding	5%	16		
	1%	21		

*For each block and seeding date the plot with the heaviest stand was considered as 100 percent.

Table 3. Estimated percent stand of mixed turfgrass about 9 weeks after seeding on seedbeds treated with Diphenatrilc and Trifluralin.

Chemical treatment	Time of seeding after seedbed treatment			
	2 wks	4 wks	6 wks	8 wks
	Percent stand*			
Diphenatrilc - Verm 30# ai/A	86	79	98	90
Trifluralin - Verm 1# ai/A	36	50	93	91
" " 1 1/2# ai/A	30	43	63	74
None	98	98	98	96
LSD treatment x time of seeding	5%	24		
	1%	32		

*For each block and seeding date the plot with the heaviest stand was considered as 100 percent.

When a mixed grass seed was sown on seedbeds treated two weeks previously with Diphenatrilite at 30 lb/A and Trifluralin at 1 and 1 1/2 lb, the resultant stand was 53%, 9% and 8% respectively, 3 weeks after seeding, in comparison with untreated checks. Delaying seeding till 4 weeks after chemical application resulted in a fairly satisfactory stand on Diphenatrilite treated soil. A fairly good stand of turf was established on Trifluralin treated seedbeds where 1 lb/A had been used and seeding was delayed for 6 weeks. At heavier rates of Trifluralin a good stand failed to develop even by delaying seeding for 8 weeks. Nine weeks after seeding, the stand of grass on 1 1/2 lb/A rate of Trifluralin plots, seeded 8 weeks after chemical treatment, was 74 percent. All other plots were in excess of 90 percent at this date.

Test No. 3, 1963

Materials and Methods

The chemical, Betasan (N-(beta-0,0 di-isopropyl dithiophosphorylethyl) benzene sulfonamide), has shown exceptional ability to control crabgrass when applied prior to germination. Because of this ability, it was felt that information in addition to its preemergence crabgrass control performance should be obtained. It was determined that the chemical should be evaluated for its effects when applied to turf seedbeds at intervals prior to seeding and on seedling turfgrass.

Test No. 3 was seeded on May 9 and 10 after seedbed preparation. A 10-20-10 fertilizer to supply 1 lb of nitrogen per 1000 sq ft had been mixed with the soil. A split-plot (grasses split) experimental design with four blocks was used. Three grasses were randomly seeded in each block in strips 4 by 15 feet in size. Four chemical treatments and a check plot were randomized within each grass strip. The grasses used and the seeding rates were: Kentucky bluegrass at 3#/M, Colonial bentgrass at 1.7#/M and creeping red fescue at 7.2#/M. All grasses had germinated by May 28 and the area was initially mowed on June 17 at a height of 2 inches. It was mowed on June 21 at 1 1/2 inches and June 24 at 1 1/4. Subsequent cuttings were at the 1 1/4 inch height. The area was irrigated during the season as required to maintain adequate soil moisture.

The chemicals were applied on June 25 after the third cutting. Dry formulations were applied by hand and the emulsion in a water spray at 272 gallons per acre and 30 psi. The grass was damp at the time of treatment.

Results and Discussion

The chemical formulations and the rates of Betasan applied as well as the turf injury ratings given at three intervals after application are presented in Table 4.

As indicated in Table 4 dry formulations of Betasan at 15 or 30 lb/A did not appreciably injure seedling turfgrasses when applied immediately after the third mowing following establishment.

Both 15 and 30 lb/A rates of liquid formulation gave some injury with the heavier rate being significantly greater than the 15 lb rate. The 15 lb rate of the emulsion caused greater turf injury than the 30 lb rate of dry formulation. As the season progressed grasses in all treatments appeared to be recover-

Table 4. Formulations and rates of Betasan applied to seedling turf and estimates of turfgrass injury at three intervals after chemical application.

Chemical and formulation	Turfgrass injury ratings* after treatment on June 25			
	# ai/A	1 wk (July 1)	2 wks (July 10)	3 wks (July 16)
Betasan (Verm)	15	0.1	0.1	0.1
" "	30	0.1	0.1	0.1
Betasan (EC)	15	0.9	1.0	0.5
" "	30	1.8	2.4	2.0
None	-	0.0	0.1	0.1
LSD 1%				0.4

*Injury rating = 0 - none, 5 - complete kill. No significant difference was obtained in injury between grasses or in interaction, treatment x grasses, so the injury ratings above are averages of the 3 grasses.

Test No. 4, 1963

Materials and Methods

This test was designed for the purpose of determining the length of time required between soil application of Betasan and reseeding with turfgrass seed. The experimental design used was a split-plot (four seeding dates split) with four blocks. Four seeding dates were randomized in strips 4 by 15 feet in size in each block. The four chemical plots plus a check were randomized on 3 by 4 foot plots in each strip.

The seedbeds were prepared and 2 formulations of Betasan, each at two rates, were applied on May 13. Materials were applied as in test No. 3. On May 27, June 10 and 16, and July 22, about 2, 4, 6 and 10 weeks after chemical application, the designated strips were seeded. The seed mixture and seeding rate were the same as in test No. 2.

Prior to seeding the soil in each plot was carefully loosened by light raking. After seeding, the plots were raked lightly, rolled and watered. Fertilizer was not incorporated into the seedbeds prior to seeding but the test area was fertilized twice during the course of the study. One lb of nitrogen per 1000 sq ft from a complete fertilizer was used in each instance.

The germination and growth of grasses on the plots seeded even 10 weeks after chemical treatment was very sparse by early September. In order to get another seeding date after chemical application the plots seeded two weeks after treatments were scarified lightly, all vegetation was removed, and they were again seeded. This seeding was 16 weeks after chemical treatment.

Results and Discussion

Stand estimates were taken at several intervals after germination on each plot. The plot with the heaviest stand present, always the check, was considered to be a 100 percent stand. The percent stand shown for treated plots was then based on that of the check plot in each block for each date of seeding.

Table 5. Estimated percent stand of grasses seeded on Betasan treated seedbeds at 2, 4, 6, 10 and 16 weeks after seedbed treatment.

Chemical and formulation	# ai/A	Weeks between chemical application and seeding				
		2	4	6	10	16
Betasan (Verm)	15	7	5	13	7	24
" "	30	4	3	3	3	9
Betasan (EC)	15	1	1	4	4	21
" "	30	T	1	T	1	5
Check	100	100	100	100	100	100

Table No. 5 gives the estimates of percent turfgrass stand as compared to the check when Betasan was applied to turf seedbeds and seeding was done at intervals of 2, 4, 6, 10 and 16 weeks after chemical application. Ten weeks after seeding a mixed grass seed the stand was reduced by over 75 percent for every chemical treatment. Seedling counts made on a few plots late in the season indicated that the lack of stand was not entirely due to reduced germination. Where seedling counts were made it was found that germination was in excess of 50% in comparison with the check. The seedlings present on treated plots were small, purplish in color and failed to make any growth. Many of these seedlings eventually died.

Summary and Conclusions

During 1962 and 1963 field studies were carried out to determine the effect of Bandane and Betasan on seedling turf and Diphenatril, Trifluralin and Betasan on seed germination and establishment. All studies were carried out on Bridgehampton silt loam soils and adequate fertility and moisture levels were maintained during the trials to prevent them from being limiting. Rate and extent of stand development was determined following the seeding on chemically treated soils and extent of injury to young turfgrass seedlings was determined where chemicals were applied following emergence. The data obtained was presented in table form for each trial.

Under the conditions of these four trials the following conclusions might be drawn:

1. Month-old seedlings of creeping red fescue and Colonial bentgrass were markedly injured with 30 and 60 lb/A rates of both vermiculite and emulsifiable concentrate forms of Bandane. Seedling Kentucky bluegrass showed serious injury only with the 60 pound rate of the emulsion. With the fescue and bentgrass the injury increased with time. Three weeks after treatment injury was slight on both grasses but at the end of six weeks it was severe particularly on fescue and more so with the EC than with the dry formulation.
2. Acceptable stands of mixed lawn grasses can be obtained by seeding 4 weeks after seedbed treatment with 30 lb/A of Diphenatril or six weeks after soil application of 1 lb/A of Trifluralin. If seeding is delayed for 8 weeks after applying a 1 1/2 lb/A rate of Trifluralin to the seedbed stand reduction is only about 1/4 at a period 9

3. Vermiculite formulations of Betasan at 15 or 30 lb/A rates applied to month old stands of Kentucky bluegrass, creeping red fescue and Colonial bentgrass caused no injury to any of the grasses. A 15 lb rate of the chemical as an emulsifiable concentrate caused moderate injury to all grasses and a 30 lb rate severely thinned or retarded the growth of all three grass species.
4. Sixteen weeks after applying EC and vermiculite formulations of Betasan to soils at 15 and 30 lb/A a mixed seeding of lawn grasses could not be successfully established. Herbicidal residues, detrimental to germination, and even more so to growth, remained in the soil even at the end of this period. Although germination was in excess of 50 percent, in comparison to the check, percent stand did not exceed 24 percent 10 weeks after seeding even when seeding was done 16 weeks after applying Betasan.

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The Use of Several Phenoxy Compounds
for Weed Control on Bentgrass

J. M. Duich, B. R. Fleming and F. Sirianni¹

There is relatively little experimental work reported on the use of phenoxy herbicides on bentgrass. Manufacturers have never recommended 2,4-D, 2,4,5-T or 2,4,5-TP on bent and varicus turf researchers have made qualified recommendations, i.e. 0.12 pounds D et T to remove clover blossoms. Sodium arsenite is probably the most widely used herbicide on bent fairways and arsenate of lead on greens.

In recent years there appears to be a greater problem with weeds in bent turf. The most troublesome are clover, knotweed, chickweed, yarrow and in some cases dandelion and plantain. Several trials with MCPP and other materials are included in this report.

Experiment One

In 1961, MCPP was sprayed on 14 bent strains at 1 lb. a.i./A in 60 gpa. Single treatments were made at three dates (June 13, August 30 and October 17) to test for bent injury and mouse-ear chickweed control. Plots were 3' x 24' and replicated three times. Results of bent injury are shown in Table 1. Discoloration for the June application was relatively minor ranging from 0 to 3 on a 0 to 10 scale. C-1 and Seaside were rated at 3 and showed effects for 10 days. Temperatures ranged in the 70's and low 80's. The August 30 treatment resulted in greater discoloration to more strains as the temperature ranged in the high 80's for a week. C-1, C-19 and Seaside showed the most discoloration followed by C-52 and Pennlu. Penncross and 4(42)3 were most tolerant with just a trace. Strains rated at 3 to 5 remained discolored for 12 to 21 days with two exceptions. One half of each strain was not treated with fungicides during the year. The untreated portion of C-1, C-19 and to a lesser extent Seaside were definitely thinned and showed this effect into June of 1962 before recovering.

Chickweed control was excellent for the June and August treatments, but poor for October when temperatures were down. Slight discoloration for several days was noted only for C-1, C-19 and Seaside from the October application.

It can be concluded from this investigation that C-1, C-10 and Seaside bents appear most susceptible to MCPP. Temperatures and any weakening of turf such as by pathogens may be important factors. Excellent chickweed control was obtained from a one pound rate for the June and August dates, but poor control resulted from the October treatment presumably due to cool temperatures.

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Table 1. Effect of MCPP (1 lb. a.i./A) on Bent Strains Sprayed at Three Dates in 1961.

Injury Rating - 0 to 10

Bent Strain	June 13	Aug. 30	Oct. 17	Ave
C-1	3	5	2	3.3
C-19	1	4	1	2.0
C-7	0	1	0	0.3
C-52	1	3	0	1.3
C-10	0	1	0	0.3
Pennlu	1	3	0	1.3
4(42)3	0	0+	0	0+
3(42)5	0	1	0	0.3
Seaside	2	4	2	2.7
Penncross	0	0+	0	0+
Astoria	0+	2	0	0.7
Highland	0+	2	0	0.7
Velvet	0+	2	0	0.7
S. German	1	2	0	1.0

Experiment Two

In 1963, clover control trials were conducted on a fairway of the Sewickley Heights Golf Club in Pittsburgh. Fairways were seeded in the fall of 1960 to a mixture of Highland, Penncross and Seaside bents and are now predominantly creeping bent with a uniform infestation of white clover. Soil is classified as a Gilpin shale and is considered a droughthy soil.

2,4,5-T and MCPP were applied at approximately five monthly intervals beginning in May. Plots were 6' x 20', replicated and sprayed at 45 gpa, with 35 psi. Table 2 shows the rates, dates of application and clover control rating approximately 30 days after treatment and on October 22. Percent control was estimated by three investigators based on three and four foot borders surrounding each plot.

It is difficult to compare dates of application for control and injury for several reasons. The June 14 treatment was re-applied on July 19 as a check on turf injury under higher temperatures since no obvious injury or discoloration was noted from the May treatment. Unfortunately a slight shower of 0.15 inches fell an hour after this retreatment and the single July 19 treatment were applied. Although control was poorer from these two treatments, injury was noted from the one pound 2,4,5-T treatment. The rain affected the clover control of the 2,4,5-T appreciably more than the MCPP. The August and September treatments covered periods when the turf was subjected to moisture stress due to water shortages.

Table 2. Clover Control From Five Treatment Dates. Ratings Shown at Approximately 30 Days and on October 22. Sewickley Heights Golf Club.

Material	Date Treated: 5/3		6/14 7/19*		7/19*		8/21		9/13	
	Rate	% Control		% Control		% Control		% Control		% Control
	a.i./A	6/14	10/22	7/19	10/22	8/21	10/22	9/13	10/22	10/22
2,4,5-T	0.25	28	0	62	30	--	--	--	--	--
2,4,5-T	0.50	62	30	67	77	20	5	67 _c	50	55
2,4,5-T	1.00	92	77	87 _a	85	48 _b	18	93 _d	85	92 _e
MCP P	1.00	97	93	87	98	75	45	90	92	98
MCP P	1.50	99	99	98	100	78	70	98	98	99
MCP P	2.00	--	--	--	--	82 _f	75	99 _g	100	100 _h

* 0.15 inches rain one hour after application

a, d Turf discolored for 21 days
 b, c, e " " " 10 days
 f " " " 3 days
 g, h " " " 7 days

The 2,4,5-T discolored the turf for all but the initial spray date at the one pound rate. The discoloration lasted 10 to 21 days but no major turf thinning was evident. MCPP discolored appreciably less and for shorter periods at the two pound rate in July, August and September.

MCPP resulted in safer and better clover control with less subsequent recovery than 2,4,5-T at 1 pound for all treatment dates. Except for the rain date, MCPP at $1\frac{1}{2}$ pounds resulted in 98 to 100 percent control without evident injury this year. It appears that bentgrass may be injured at about the 2 pound rate of MCPP. The $\frac{1}{4}$ and $\frac{1}{2}$ pound rates of 2,4,5-T are not very effective for clover control. MCPP appeared effective on scattered yarrow in the rough.

Experiment Three

A single treatment for clover control was also made at the Shannopin Country Club in the Pittsburgh area on May 3. Procedures similar to Experiment Two were used. Materials and rates are shown in Table 3 with a final control rating on September 13. 2,4-D gave poor clover control (10-15%) and the 2,4,5-T and MCPP results were similar to Sewickley.

Experiment Four

An experimental plot of Seaside putting green bent infested with mouse-ear chickweed, common plantain and dandelion was treated with MCPP; 2,4-D; MCPP:2,4-D combination; 2,4,5-T and Dicamba at various rates on September 6, 1963 at University Park, Pennsylvania. Similar procedures described earlier were used in spraying.

Materials, rates of application, percent control of the three weeds and injury ratings for the Seaside are shown in Table 4. Weed control is based on actual weed counts prior to spraying and a final count on November 21.

MCPP and MCPP:2,4-D combination treatments gave 90 to 100 percent control of the three weeds. Dicamba was very effective on chickweed and dandelion, 99-100, but poor to fair on common plantain, 10 to 60 percent at varying rates. 2,4,5-T was effective on dandelion, 93-96, and fair on chickweed and plantain, 42-75. 2,4-D was fair on chickweed and very effective on plantain and dandelion. It may be necessary to combine 2,4-D with Dicamba for broad-spectrum weed control with this new material.

Injury ratings on a 0 to 10 scale are shown in Table 4 for September 15 and September 30, 9 and 24 days following application. All materials discolored the Seaside to what would be considered an objectionable degree except the Dicamba at $\frac{1}{4}$ pounds at the 9 day rating period which showed the optimum. The severity of injury is brought out by the 24th day on September 30. MCPP and Dicamba showed recovery at all but the highest rates. All other treatments were apparently injuring the Seaside, particularly the 2,4-D.

Due to the variability of injury to the various strains as shown in Experiment One it will be necessary to thoroughly test the newer chemicals on specific strains and under various stress treatments for proper evaluation.

Table 3. Percent Clover Control at Shannopin Country Club from Treatment on May 3, 1963.

<u>Material</u>	<u>Rate</u>	<u>% Control</u> <u>Sept. 13, 1963</u>
2,4-D	0.5 a.i./A	10
"	1.0 "	15
2,4,5-T	0.5 "	65
"	1.0 "	87
MCPP	1.0 "	91
"	1.5 "	100

Table 4. Effect of Herbicides on Seaside Putting Green Bent, Chickweed, Plaintain and Dandelion. Applied 9/6/63

<u>Material</u>	<u>a.i./A</u>	<u>% Control - 11/21/63</u>			<u>Injury*</u>	
		<u>Chickweed</u>	<u>Plaintain</u>	<u>Dandelion</u>	<u>9/15</u>	<u>9/30</u>
MCPP	1.0	100	93	90	3.0	0
MCPP	1.5	100	94	98	3.7	0
MCPP	2.0	100	94	98	4.7	0.6
MCPP:2,4-D (2:1)	1.5	100	92	100	3.0	2.3
MCPP:2,4-D (3:1)	1.5	100	96	100	3.7	1.7
MCPP:2,4-D (4:1)	1.5	98	96	100	4.0	1.7
2,4-D	1.5	50	98	100	3.3	5.0
2,4,5-T	1.0	50	42	93	5.0	0.3
2,4,5-T	1.5	75	66	96	6.7	1.3
2,4,5-T	2.0	75	68	99	8.0	3.7
Dicamba	0.25	100	10	99	1.0	0
Dicamba	0.50	100	50	99	2.7	0
Dicamba	1.0	100	60	100	6.3	0.7

* Injury scale 0 to 10, 0 = none

THE CONTROL OF CHICKWEED AND CLOVER BY PHENOXY PROPIONICS
AND DICAMBA COMPOUNDS IN BENTGRASS

L. M. Callahan and R. E. Engel¹

The methylated phenoxy propionic compounds have found increased use in recent years as a turf herbicide. However, there has been concern as to the relative safety of these compounds on bentgrass turfs. Furthermore, variability in formulation of the same compounds may also alter the degree of phytotoxicity.

With these factors in mind, tests were conducted to compare the degree of phytotoxicity of three formulations of MCPP² compounds. In addition, a non-methylated phenoxy propionic³ and a dicamba⁴ compound were included in order to compare chemical phytotoxicity.

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²Key to chemical and formulation abbreviations:

- a. 2-(MCPP), DMA - Chipco [2-(2-methyl-4-chlorophenoxy) propionic acid] formulated as the dimethylamine salt.
- b. 2-(MCPP), K salt - Morton [2-(2-methyl-4-chlorophenoxy) propionic acid] formulated as the potassium salt.
- c. 2-(MCPP), K salt - Cleary [2-(2-methyl-4-chlorophenoxy) propionic acid] formulated as the potassium salt.

³Silvex, BEE - Amchem [2-(2,4,5-trichlorophenoxy) propionic acid] formulated as the butoxy ethanol ester.

⁴Banvel D, DMA - Velsicol [2-methoxy-3,6-dichlorobenzoic acid] formulated as the dimethylamine salt.

Materials and Methods

Three formulations of MCP P at 1 and 1-1/2 pounds, 1 pound of silvex, and 1/2 pound of banvel D were applied on July 29, 1963. All applications were made on a basis of pounds per acre of active ingredient. The treatments were made on a watered bentgrass fairway. Plot size was 4 x 15 feet with 2-foot borders and treatments replicated three times.

Turf injury was recorded on August 5, 1963. Chickweed, clover, and dandelion control measurements were recorded August 27 and October 14, 1963.

Results and Discussion

Only slight to moderate turf burn occurred seven days after treatment. Silvex, however, caused approximately 30 percent foliage burn. All three MCP P compounds produced an estimated 10 percent foliage burn at 1-1/2 pounds with only very slight burn at 1 pound. Banvel D caused no discernible foliage burn.

Two months after treatment, foliage burn from the chemical treatments was largely obscured by regrowth. Mouse-ear chickweed control of 56 percent or more was obtained for all the chemicals at all rates (Table 1). The three MCP P compounds at 1-1/2 pounds gave the best control of chickweed.

The order of effectiveness in reducing the clover population (Table 2) was as follows: (1) banvel D at 1/2 pound; (2) MCP P-DMA at 1-1/2 pounds; (3) silvex at 1 pound; and (4) MCP P-DMA at 1 pound.

The effectiveness of these chemicals in controlling dandelion was not as good as can be obtained with some phenoxy materials. The chemicals which gave the best control (Table 3) are MCP P-K salt at 1-1/2 pounds, banvel D, MCP P-DMA at 1-1/2 pounds, and silvex, respectively.

Table 1. Control of mouse-ear chickweed in a watered bentgrass turf with phenoxy propionic and dicamba compounds applied July 29, 1963.

Chemical and Formulation	Rate, lb/A	Chickweed Control (Percent)	
		August 27, 1963	October 14, 1963
2-(MCP), DMA	1-1/2	87.4	89.4
2-(MCP), K salt	1-1/2	80.6	75.0
2-(MCP), K salt	1-1/2	80.6	75.0
2-(MCP), DMA	1	70.9	70.6
2-(MCP), K salt	1	68.0	68.7
Silvex, BEE	1	64.1	70.6
2-(MCP), K salt	1	64.1	56.2
Banvel D, DMA	1/2	58.3	66.9

Table 2. Control of clover in a watered bentgrass turf with phenoxy propionics and dicamba compounds applied July 29, 1963.

Chemical and Formulation	Rate, lb/A	Clover Control (Percent)	
		August 27, 1963	October 14, 1963
Banvel D, DMA	1/2	93.0	90.1
2-(MCP), DMA	1-1/2	93.0	90.1
Silvex, BEE	1	90.9	90.1
2-(MCP), DMA	1	90.9	85.2
2-(MCP), K salt	1-1/2	83.9	86.7
2-(MCP), K salt	1-1/2	81.1	81.8
2-(MCP), K salt	1	79.0	83.7
2-(MCP), K salt	1	60.1	71.9

Table 3. Control of dandelion in a watered bentgrass turf with phenoxy propionics and dicamba compounds applied July 29, 1963.

Chemical and Formulation	Rate, lb/A	Dandelion Control (Percent)	
		August 27, 1963	October 14, 1963
2-(MCP), K salt	1-1/2	79.8	72.7
Banvel D, DMA	1/2	71.2	67.6
2-(MCP), DMA	1-1/2	71.2	50.6
Silvex, BEE	1	68.7	52.4
2-(MCP), K salt	1-1/2	68.7	39.4
2-(MCP), DMA	1	65.7	49.4
2-(MCP), K salt	1	61.4	40.3
2-(MCP), K salt	1	54.1	28.2

Summary

Treatments were made on an irrigated bentgrass turf in late July 1963. The purpose of these tests was to determine the degree of phytotoxicity of the three MCP formulations and to compare their herbicidal effectiveness with that of silvex and banvel D.

The phenoxy propionics and dicamba compounds all gave good chickweed control. However, this control did not approach completeness; possibly this was due to the application date of the treatments.

The three MCP formulations, at 1-1/2 pounds, gave the highest percentage of chickweed control one month after treatment. By 2-1/2 months, their degree of effectiveness had changed very little. Injury to the bentgrass from the MCP compounds was slight and then only evident at the higher rate.

The following indications are based on the percentage of control obtained by the MCP compounds under the conditions of this test.

- (1) The formulation of the MCP P compounds appear to influence their degree of effectiveness as an herbicide. The most soluble salt tended to be the most effective (and conversely).
- (2) In controlling chickweed, the order of effectiveness indicates that the DMA formulation is most phytotoxic followed by the K salt.

The treatments with silvex and banvel D at the rates applied appeared to be less effective in controlling chickweed as compared with the MCP P formulations. Better control could probably have been obtained with higher rates of silvex and banvel D but these were not attempted due to concern for safety of the bentgrass.

In general, the MCP P compounds seem to be less effective in controlling clover than non-methylated phenoxy propionics. However, this tendency may be eliminated by an increase in rate and/or by using a more active formulation.

CLOVER AND CHICKWEED CONTROL IN LAWN AND FAIRWAY TURF¹J. A. Jagschitz and C. R. Skogley²

Clover (*Trifolium repens*) and mouseear chickweed (*Cerastium vulgatum* L.) in lawn and fairway turf are objectionable weeds. Selective chemical control of these weeds with no injury to the turf has been the goal of numerous researchers.

Four tests were initiated to evaluate various chemicals, formulations, rates and combinations of chemicals for the control of clover and mouseear chickweed. One of these tests also investigates the control of stitchwort (*Stellaria graminea* L.).

Materials and Methods

The experimental design of each of the four tests was three complete randomized blocks. Individual plot size was 4 x 10 feet. All dry formulations were applied by hand. Liquid formulations were applied as water sprays using a hand sprayer regulated at 30 psi with a fan-type nozzle. The chemicals, formulations and rates used are presented in the table for each test. The following is the complete data on the chemicals used:

Dicamba was 2-methoxy-3,6-dichlorobenzoic acid, dimethylamine salt, 4# ae/gal, vermiculite 1%, attapulgite 1% (Velsicol); endothall was 7-oxabicyclo-(2.2.1) heptane-2,3-dicarboxylic acid, 2# ai/gal and formulated with silvex, 1.5# ai each/gal (Pennsalt); picolinic acid was 4-amino-3,5,6-trichloropicolinic acid, potassium salt, 2# ai/gal (Dow); silvex was 2-(2,4,5-trichlorophenoxy) propionic acid, butoxy ethanol ester, 4# ae/gal (Amchem), 2-ethyl hexyl ester, 4# ae/gal and oleoyl 1,3-propylene diamine salt, 4# ae/gal (Diamond Alkali); 2,4-D was 2,4-dichlorophenoxyacetic acid, dimethylamine salt, 4# ae/gal and butoxy ethanol ester, 4# ae/gal (Amchem), 2-ethyl hexyl ester, 4# ae/gal and oleoyl 1,3-propylene diamine salt, 4# ae/gal (Diamond Alkali), alkanolamine salt, 4# ae/gal (Dow), triethylamine salt, 18% bar (Chipman); 2,4,5-T was 2,4,5-trichlorophenoxyacetic acid, butoxy ethanol ester, 4# ae/gal (Amchem), 2-ethyl hexyl ester, 4# ae/gal and oleoyl 1,3-propylene diamine salt, 4# ae/gal (Diamond Alkali); 2-(MCPP) was 2-(2-methyl-4-chlorophenoxy) propionic acid, dimethylamine salt, (dextro rotary isomer), 2# ae/gal (Chipman), d and l isomers (CMPP) .832# ae/gal + 2,4-D .832# ae/gal + mixed chlorophenoxy acetic acid .312# ai/gal (Green Cross).

Visual clover and stitchwort cover estimates were made for each plot. Percent control was based on the reduction when compared to the average cover of the check plots. Mouseear chickweed cover estimates were made for each plot before and after treatment in tests I and II. Percent control was based on the reduction after considering the variation of the check plots. In tests III and IV control of mouseear chickweed was based on the check plots as was done for clover and stitchwort.

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Visual turf injury estimates were made in tests I and II on a scale of 0-5 with 0 being no injury and 5 complete kill. In tests III and IV estimates were made of the area of the plot which had brown or bare turf. Bare turf was considered to be exposed soil.

Maximum temperatures and rainfall relative to each test

Test	Test date	Day of test	10 days after test		Before ^x test	After test	Days after test		
			Highest	Av.			10	11-20	21-30
I	5/29/62	62	88	74	.55(4)*	1.41(7-8)*	1.44	1.97	2.13
II	9/14/62	80	80	69	.24(8-9)	.18(4)	.93	2.69	5.56
III	5/27/63	67	79	72	1.60(8-9)	1.43(2-3)	1.74	.72	.32
IV	6/12/63	66	80	74	.42(1)	.17(3)	.49	.09#	.75

x = Tests I and II were irrigated before chemicals were applied.

* = The interval in days between the time it rained and the day of treatment.

= Temperatures during the last eight days of this period had an average maximum of 90°F with 94°F being the highest day.

Test I and II

These tests were located on lawn turf at the turfgrass research area of the University of Rhode Island. The turf consisted of Merion and Kentucky bluegrass and some fescue. Block A of test I had a fair proportion of Colonial bentgrass present. The turf was mowed at a height of 1 1/2 inches.

Test I and II consisted of 14 and 32 chemical treatments respectively. Each block had two check plots. Dry formulations were applied to moist turf. Sprays were applied at 272 gpa in test I and at 136 gpa in test II. Test I treatments were applied on May 29, 1962 and test II on September 14, 1962. Turf injury estimates were made on June 11 and 26, 1962 for test I and on October 1, 1962 for test II. Weed control estimates were made on June 13, 1963 for both tests.

Test III and IV

These two tests were located on fairway turf at the Point Judith Country Club, Narragansett, Rhode Island. The turf consisted of creeping bentgrass, Kentucky bluegrass, annual bluegrass, creeping red fescue, and velvet bentgrass. The turf was mowed at a height of about 5/8 inch.

Test III and IV consisted of 45 and 10 chemical treatments respectively. Test III had 7 check plots per block while test IV had 3 per block. Dry formulations were applied to slightly moist turf. Sprays were applied at 54.5 gpa. Test III treatments were applied on May 27, 1963 with the exception of six treatments which were applied on June 12 the same day that test IV chemicals were applied.

Observations of some discoloration were noted on June 3 in test III. Percent brown or bare turf estimates were made on July 3 and July 23, 1963 for both tests. Weed control estimates were made for each test on October 1, 1963.

Results and Discussion

Test I

Estimates of weed control and turf injury from the application of fourteen chemicals to lawn turf on May 29, 1962 are presented in Table I. Treatments of 2,4-D did not give over 38% control of either clover or mouseear chickweed. A combination of 2,4-D + silvex at 1/2 lb each produced 33% chickweed control while clover control was 76%. Silvex alone at 1 lb controlled 82% of the clover and 74% of the chickweed. The liquid formulation of dicamba at the 1/2 lb rate controlled at least 97% of both weeds. At comparable rates there was no significant difference between the dicamba formulations although the liquid form was more effective. Turf injury was not severe from any of the treatments except with the high rates of dicamba. Injury was chiefly to Colonial bentgrass in block A.

Table I. Effect of various chemicals applied on May 29, 1962 in lawn turf for the control of clover and mouseear chickweed.

Trt. No.	Chemical and formulation	# ae/A	Percent control 6/13/63		Turf injury (0-5)	
			Clover	Mouseear chickweed	6/11/62	6/26/62
1	dicamba *	.5	97	98	.3	.0
2	"	1.0	99	100	.6	.0
3	"	1.5	99	100	.9	.0
4	"	3.0	99	99	1.4	.4
5	dicamba* (Verm)	1.0	84	92	.6	.0
6	" "	2.0	92	87	.6	.1
7	" "	3.0	99	100	1.0	.3
8	" "	4.0	97	100	1.4	.9
9	dicamba* (Atta)	2.0	96	98	.6	.1
10	2,4-D **	1.0	27	38	.1	.0
11	2,4-D ***	1.0	11	11	.3	.0
12	2,4-D (bar) xxx	-	16	6	.0	.0
13	silvex xx	1.0	82	74	.5	.0
14	2,4-D + silvex x	.5+.5	76	33	.2	.0
15-16	checks	-	-	-	.1	.0
LSD	5%		31	38		
	1%		42	52		
Average percent cover in check plots			32	6		
* dimethylamine salt			x 2-ethyl hexyl ester			
** oleoyl 1,3-propylene diamine salt			xx butoxy ethanol ester			
*** alkanolamine salt			xxx triethylamine salt			

Test II

Data presented in Table II show the results from the application of thirty-two chemical treatments on September 14, 1962 in lawn turf. All treatments gave at least 96% control of clover with the exception of the following: endothall at 1 lb produced 89% and 2,4-D at 1 lb 83% (1/2 lb rate 96%). Chickweed control was 90% or better with all but six of the chemical treatments and these were 2,4,5-T at 1/2, 1, and 1 1/2 lbs, endothall at 1 lb, endothall + silvex at 1/2 lb each and the vermiculite formulation of dicamba at 1/4 lb. Turf injury was chiefly light greening and yellowing. Silvex produced the most injury.

Test III (May 27 treatments)

Weed control and turf injury from thirty-nine chemical treatments applied on May 27 and six applied on June 12, 1963 are presented in Table III. Poor control of clover, chickweed and stitchwort was obtained with 2,4-D. Chickweed and stitchwort control was poor using 2,4,5-T. Clover control with 2,4,5-T was not consistent although two treatments did give over 90% control. There was some variability in weed control among rates and formulations of silvex. Clover control was 96% at 1 and 1 1/2 lbs with two of the three formulations. Chickweed and stitchwort control was also variable and ranged from 79% to 97% at the 1 1/2 lb rate.

Dicamba at 1/4 lb in the liquid form and 1/2 lb in the vermiculite form produced 99% control of clover. Chickweed control was in the 90% range using 1 lb of either form while stitchwort control ranged from 82 to 92%. Adding 1 lb of 2,4-D to 1/4 lb dicamba increased chickweed control to 97% but had little effect on stitchwort. The formulation of 2-(MCP) + 2,4-D + mixed chlorophenoxy acetic acid at 1.1 + 1.1 + .4 lbs produced 96% and 100% control of clover and chickweed respectively. Stitchwort control at this rate was 49% but was 96% at the higher rate. Picolinic acid at .125 lbs gave 98% control or better of the three weeds. Endothall gave poor control of all weeds. The endothall + silvex formulation at 1.5 lbs each produced 85% control of clover and stitchwort, but only 48% control of chickweed.

Turf injury was slight for most treatments. Although variable, certain rates of silvex, endothall + silvex, and picolinic acid caused the most turf injury. Turf injury was not increased by adding 1 lb of 2,4-D to dicamba. Endothall and endothall + silvex, within one week after treatment, produced moderate temporary turf discoloration.

Test III (June 12 treatments)

Application of 2-(MCP) at 3/4 lb gave at least 99% control of clover, chickweed and stitchwort. The addition of 1 lb of 2,4-D to the 1 1/2 lb rate gave some increase in turf injury. Turf injury was more severe than that of any of the chemical treatments applied in May, but is probably due to the difference in date of application. This also could have influenced weed control. About twelve days after 2-(MCP) was applied dry conditions persisted and the temperature was in the 90's for several days. Realizing that comparisons among 2-(MCP) and other chemicals in test III would be limited, because of different application dates, test IV was initiated.

Table II. Clover and mouseear chickweed control in lawn turf treated on September 14, 1962 with various chemicals.

Trt. No.	Chemical and formulation	# ai/A	Percent control (6/13/63)		Turf injury (0-5) 10/1/62
			Clover	Mouseear chickweed	
1.	dicamba *	.25	100	99	.0
2.	"	.5	100	98	.0
3.	"	1.0	100	100	.0
4.	"	1.5	100	100	.1
5.	dicamba * (Verm.)	.25	96	75	.0
6.	" "	.5	100	100	.0
7.	" "	1.0	99	100	.1
8.	" "	1.5	100	100	.0
9.	silvex ^{xx}	.5	99	91	.2
10.	"	1.0	99	100	.5
11.	"	1.5	100	99	.9
12.	2,4,5-T ^{xx}	.5	98	66	.0
13.	"	1.0	99	75	.1
14.	"	1.5	99	52	.2
15.	2,4-D ^{xx}	.5	96	90	.0
16.	"	1.0	83	90	.0
17.	"	1.5	93	99	.2
18.	dicamba * + silvex ^{xx}	.25+ .5	100	99	.1
19.	" "	.25+1.0	100	100	.3
20.	" "	.5 + .5	100	100	.1
21.	" "	.5 +1.0	100	100	.3
22.	dicamba * + 2,4,5-T ^{xx}	.25+ .5	100	100	.1
23.	" "	.25+1.0	100	100	.1
24.	" "	.5 + .5	99	100	.0
25.	" "	.5 +1.0	100	100	.1
26.	dicamba * + 2,4-D ^{xx}	.25+ .5	100	100	.0
27.	" "	.25+1.0	100	100	.0
28.	" "	.5 + .5	100	100	.0
29.	" "	.5 +1.0	100	100	.0
30.	endothall	1.0	89	31	.0
31.	endothall + silvex	.5 + .5	98	62	.0
32.	" "	1.0 +1.0	98	90	.0
33-34	checks	-	-	-	.0
LSD 5%			5	25	
1%			6	33	
Average percent cover in check plots			23	4	
* dimethylamine salt			xx butoxy ethanol ester		

Table III. Evaluation of several chemicals applied on May 27 and June 12, 1963 to fairway turf for the control of clover, mouseear chickweed and stitchwort.

Trt. No.	Chemical and formulation	# ai/A	Percent control			Percent brown or bare turf	
			Clover	Mouseear chickweed	Stitchwort	7/3/63	7/23/63
<u>APPLICATION 5/27</u>							
1	2,4-D ^x	.75	25	33	13	0	1
2	"	1.0	4	36	28	1	1
3	"	1.5	46	47	34	1	2
4	2,4-D ^{**}	.75	62	12	35	7	3
5	"	1.0	4	18	32	1	0
6	"	1.5	19	24	38	1	1
42	2,4-D [*]	1.0	19	6	12	0	1
43	2,4-D ^{xx}	1.0	0	64	0	0	1
7	2,4,5-T ^x	.75	25	24	0	1	1
8	"	1.0	63	27	0	10	2
9	"	1.5	98	3	4	1	1
10	2,4,5-T ^{**}	.75	58	21	0	1	1
11	"	1.0	91	0	28	1	1
12	"	1.5	74	12	20	2	2
44	2,4,5-T ^{xx}	1.0	57	33	23	3	2
13	silvex ^x	.75	93	70	19	4	1
14	"	1.0	97	76	52	7	3
15	"	1.5	96	86	87	12	6
16	silvex ^{**}	.75	88	61	83	5	1
17	"	1.0	100	94	75	3	2
18	"	1.5	98	79	97	11	3
45	silvex ^{xx}	1.0	75	64	61	13	4
19	dicamba [*]	.25	99	61	52	1	4
20	"	.5	100	94	85	6	3
21	"	1.0	100	99	82	7	3
22	dicamba [*] (Verm)	.25	76	33	54	3	2
23	" "	.5	99	83	61	2	3
24	" "	1.0	100	92	92	1	2
25	dicamba ^{**} +2,4-D [*]	.25+1.0	100	97	54	0	2
26	" "	.5 +1.0	99	100	68	3	3
27	" "	1.0 +1.0	100	100	94	7	4
34	2-(MCPD)+2,4-D ¹	1.1 +1.1	96	100	49	2	2
35	" "	1.7 +1.7	99	97	96	4	2
36	picolinic acid [#]	.125	100	98	99	3	2
37	" "	.25	100	99	100	10	4
38	endothall	1.0	21	18	19	1	1
39	"	1.5	58	62	0	1	1
40	endothall+silvex	1.0 +1.0	58	45	59	2	2
41	" "	1.5 +1.5	85	48	85	12	3

Table III (Cont'd.)

Trt. No.	Chemical and formulation	# ai/A	Percent control			Percent brown or bare turf	
			Clover	10/1/63 Mouseear chickweed	Stitch-wort	7/3/63	7/23/63
<u>APPLICATION 6/12</u>							
28	2-(MCPP) *	.75	99	100	99	28	16
29	"	1.0	99	100	99	26	13
30	"	1.5	100	100	100	23	14
31	2-(MCPP) *+2,4-D *	.75+1.0	96	100	99	22	10
32	"	1.0 +1.0	99	100	83	26	12
33	"	1.5 +1.0	99	100	100	57	21
46-52	checks	-	-	-	-	1	1

LSD	5%		29	39	41		
	1%		38	45	55		

Average percent cover of check plots			28	11	23		

x	= 2-Ethyl Hexyl ester.			* = dimethylamine salt.			
xx	= butoxy ethanol ester.			** = oleoyl 1,3-propylene diamine salt.			
				# = potassium salt.			
1	= formulation of 2-(MCPP) (d and l isomers), 2,4-D, and mixed chlorophenoxy acetic acid (include .4 and .6 in rates mentioned above for the latter.						

Test IV

Table IV presents the results from the application of ten chemical treatments on June 12, 1963 in fairway turf. Dicamba at 1/2 lb, 2-(MCPP) and silvex at 3/4 lb gave at least 90% control of clover and 100% control of mouseear chickweed. Clover control using 2,4,5-T at 3/4 lb was over 90% but chickweed control was poor even at 1 1/2 lbs. Poor control of either weed was obtained with 2,4-D. Turf injury was moderate to severe with all chemicals. Silvex and 2,4,5-T at 1 1/2 lbs produced the most injury.

General Discussion

The results of these four tests indicate that the best time for clover and chickweed control may be the fall. Certain chemicals or rates gave good control only in the fall. Late spring applications could lead to serious turf injury since dry spells and hotter temperatures are more likely as summer approaches. The fall of '62 was followed by a very severe winter which caused considerable turf injury through the Northeast. Possibly chickweed is more susceptible in the fall but good control may have been the combination of chemically weakened plants and the severe winter. Chickweed cover estimates made of the untreated plots in December and again in June indicated that there was a 50% reduction.

Observations (not presented) were made on the effect of the chemical treatments on the dandelion population. 2,4-D alone and in combination with dicamba

and 4 lbs gave fair to good control. In the fall test all chemicals gave good control of dandelion except endothall, endothall + silvex and the 1/4 lb rate of dicamba.

Table IV. Control of clover and mouseear chickweed in fairway turf treated on June 12, 1963 with various chemicals.

Trt. No.	Chemical and formulation	# ae/A	Percent control 10/1/63		Percent brown or bare turf	
			Clover	Mouseear chickweed	7/3/63	7/23/63
1	dicamba *	.5	100	100	23	4
2	"	1.0	100	100	30	5
3	2-(MCP) *	.75	90	100	27	5
4	"	1.5	94	100	24	5
5	2,4-D ^{xx}	.75	41	49	17	2
6	"	1.5	55	52	28	7
7	2,4,5-T ^{xx}	.75	99	55	20	2
8	"	1.5	91	46	43	12
9	silvex ^{xx}	.75	97	100	55	22
10	"	1.5	99	100	63	30
11-13	checks	-	-	-	2	1
LSD	5%		37	45	23	
	1%		51	62	31	
Average percent cover in check plots			28	11		
* dimethylamine salt			xx butoxy ethanol ester			

Conclusions

Four tests were initiated to study the effect in lawn and fairway turf of various chemicals, formulations, rates and dates of application on the control of clover, mouseear chickweed, and, in one test, stitchwort. From the results of these tests the following conclusions were reached:

1. The most effective and consistent chemicals used for clover, chickweed and stitchwort control were dicamba, 2-(MCP), silvex and picolinic acid. Combinations of 2,4-D with dicamba and 2-(MCP) were also effective.
2. Turf injury with dicamba and 2-(MCP) was less than that produced by silvex. Colonial bentgrass was less tolerant to dicamba and silvex than bluegrass or fescue.
3. Dry formulations of dicamba at low rates are not as effective as liquid formulations.
4. Fall applications of certain chemicals gave better weed control with less turf injury than did spring applications.

IMPROVED HERBICIDES FOR WEED CONTROL IN TURF

H. A. Pass and B. J. Watt ¹

The range of broad-leaf weed species in lawns and turf which are not controlled by 2,4-D includes Ground Ivy (Nepeta hederacae), Heal-all (Frunella vulgaris), Black Medick (Medicago lupulina), Common Chickweed (Stellaria media), Mouse-ear Chickweed (Cerastium vulgatum), Stitchwort, Canada Violet, Clover, English Daisy (Bellis perennis) and Carpetweed (Mollugo verticillata), amongst others. These weeds have gradually become more prominent in established turf with the wide use of 2,4-D. In extreme cases, lawns treated with 2,4-D still have a very "weedy" appearance following treatment and some home-owners have reverted to hand weeding or lawn renovation which gives temporary relief until the same species re-establish themselves.

Many home-owners in the past have resorted to using harsh treatments such as 2,4-D + 2,4,5-T + potassium cyanate in a desperate effort to rid their lawns of these problem weeds, usually with serious turf damage. A product was needed which would control a broad range of weeds including the "hard-to-kill" species as well as dandelions and plantains without causing turf injury.

The herbicide 2,4,5-TP was introduced as a control for some of these "hard-to-kill" weed species such as the chickweeds and clovers but it is limited as to time of application, which must be in spring or fall, and even then a degree of grass injury can be expected.

Some years ago our Research and Technical Department commenced an extensive series of tests employing a broad range of herbicide combinations. A large number of these were tested on the stubborn weed species without any success.

In carrying out this plot work with herbicides on turf we found it was impossible to find uniformly weedy lawns of sufficient size to permit more than two or three replicates of each treatment when we used standard 100 sq. ft. plots.

Through trial and error we found the most satisfactory plot size to be an area of 5 ft. x 5 ft. In addition to the advantage of allowing more plots on a given area we learned that these comparatively small plots were much easier to observe and read. Six inch stakes, pre-pointed at one end, measuring tape and strong light-weight cord and the use of 25 sq. ft. plots makes it possible to utilize a large number of lawns on differing soil types, grass and weed species and grass textures and to test a large number of different herbicides in a single season under all sorts of conditions.

¹ Technical Director and Technical Supervisor, respectively. Green Cross

If all the mechanical details are worked out beforehand, including laboratory measured quantities of herbicides and the use of a standard spray volume of 16 fl. oz. per 25 sq. ft. plot, a large number of plots can be sprayed quickly and accurately.

It is not our intention to review the exhaustive series of herbicide combinations which proved unsatisfactory in our turf tests. It is proposed, rather, to concentrate on the end results of this program with the presentation of factual information on specific herbicide combinations which have shown synergism and which have proven to be effective not only in our field testing program but in the broader and more demanding proving ground of commercial usage.

This includes use by home owners, commercial applicators and turf maintenance experts during the years in which a commercial formulation has been available to the consumer market. Acceptance has been far greater than anticipated.

Ground Ivy (Nepeta hederacea) grows rampant in the lawns of a number of Montreal suburbs and we had no difficulty in screening many new mixtures on this weed. After completing a number of test series we found that the most effective combinations were those in which MCPP (dextro-rotatory isomer of 2(4 chloro-2-methylphenoxy) propionic acid) were employed. MCPP when used by itself is effective on chickweed but does not give satisfactory control of dandelions and plantains. It is also very slow acting and when used alone it takes up to 5 weeks for the susceptible weeds to show the same degree of effect as might be expected within 10 days after application of 2,4-D or Silvex.

The following results indicate the degree of control obtained in some of our tests on Ground Ivy, showing the definite synergism of MCPP in combination with 2,4-D and the high degree of control obtained:

TREATMENT (ACID EQUIVALENT) PER ACRE	EFFECT ON GROUND IVY 6 WEEKS AFTER TREATMENT
MCPP 8 oz.	No kill
MCPP 16 oz.	No kill
2,4-D 32 oz.	No kill
2,4-D 32 oz. + 2,4,5-T 32 oz	No kill
MCPP 4 oz. + 2,4-D 16 oz	95% kill
MCPP 8 oz. + 2,4-D 16 oz	98% kill
MCPP 8 oz. + 2,4-D 16 oz + 2,4,5-T [*] 6 oz	100% kill

* 2,4,5-T Crude (Mixed chlorophenoxyacetic acids). This is milder and less phytotoxic to grass than ordinary 2,4,5-T.

Following the discovery of its effectiveness on Ground Ivy this three-way mixture was tested on as many of the "hard-to-kill" weeds as possible.

HEAL-ALL: Special attention was paid to Heal-all (Prunella vulgaris) which is completely unaffected by 2,4-D and only slightly affected by brush killers. Most turf authorities state: "2,4,5-T not much better than hand weeding". Direct comparison in lawn plots showed that this synergistic combination gave exceptionally quick and complete kill of Heal-all whereas 2,4-D alone or in other herbicide mixtures tested gave no control.

It is perhaps noteworthy to state here that the Canadian product registration authorities were at first most skeptical about the label claim that this combination would control Prunella vulgaris, however, this claim has been completely substantiated in many tests including University trials as well as in commercial usage.

CHICKWEED: Chickweeds and stitchwort are extremely difficult to eradicate with 2,4-D and can seriously invade turf especially if the area is fertilized heavily. Our tests indicated that either Silvex or MCPP combined with other phenoxyacetic herbicides gave excellent control, however, there was a degree of grass injury which was undesirable from the Silvex combination which was not present with the MCPP formulations.

BLACK MEDICK: (Medicago lupulina) usually becomes a problem in mid-season when Silvex, which will control it, cannot be used because of turf damage. The three-way combination gives very rapid and complete kill of this troublesome "yellow clover".

CLOVER: White Dutch Clover, which often grows in dense patches throughout the lawn, is readily controlled by the combination of herbicides. Both the MCPP and the 2,4,5-T in the three-way mixture contribute to more complete clover eradication.

ENGLISH DAISY: (Bellis perennis) Excellent kill of this Western Canada (B.C.) weed may be achieved by spraying in May when the plants are in full bloom.

CANADA VIOLET: It is interesting to note that this is the one plant which we have found to be not well controlled by the herbicide mixture. A late spring treatment will reduce the stand somewhat but will not eradicate this weed. Fortunately, it is not a widespread weed in lawns.

This by no means exhausts the list of "hard-to-kill" weeds controlled by this mixture, however, the above-mentioned are usually considered the most common problem weeds in Canadian lawns. In addition to these weeds the mixture provides outstanding control of the common
 dandelion and other 2,4-D susceptible species.

INJURY: This particular combination has an excellent record of safety to turf in commercial usage. In addition, several workers have reported no injury to bluegrass turf even when used at twice the recommended dosage. It is not suggested for use on bent grasses, of course, as the 2,4-D content at the recommended rate will affect the bent grass.

FERTILIZER COMBINATIONS: The mixture of 2,4-D, MCPP and 2,4,5-T (Mixed trichlorophenoxyacetic acids) has been evaluated for weed control when impregnated on turf fertilizers (20-10-5), (10-6-4), (7-7-7). Excellent weed control has resulted under good growing conditions when applied evenly to give good coverage of the weeds. At high rates (double the normal rate for fertilizer) Ground Ivy was browned and killed completely within 5 days, a much more spectacular kill than the normal spray application, although it must be borne in mind that the herbicide dosage rate in this instance was considerably more than double the recommended rate applied as a spray.

FUTURE DEVELOPMENTS IN TURF HERBICIDES? Dicamba certainly is a most promising herbicide for turf weeds and our current investigations include mixtures of dicamba with other herbicides. Our tests to date have shown that relatively high rates of dicamba are required to kill some of the common weeds including dandelions and it is therefore, advantageous to include 2,4-D with dicamba in combinations. We have found that in mixtures where dicamba is used at low rates, for its excellent chickweed, knotweed and clover control, the dosage of 2,4-D must be maintained at the same rate per acre as when used alone for dandelions. More work must be done to establish the maximum safe dosage level of dicamba to trees and other ornamentals. At 1 lb per acre there appears to be danger of killing such trees as spruce by root absorption of dicamba.

SUMMARY

"KILLEX", the trade name of this three-way herbicide mixture of MCPP, 2,4-D and 2,4,5-T Mixed isomers, has been widely tested by Canadian turf weed workers at Experiment Stations and Universities with outstanding results against most of the "problem" broad-leaf turf weeds. In commercial usage this combination has proven to be the most versatile and also the most popular weed killer for lawns available in Canada today. It is anticipated that, following the release of substantiating data from weed workers in the U.S.A., this product will be available from U.S. formulators.

CHEMICAL WEED CONTROL IN FOREST TREE NURSERY STOCK

T. R. FLANAGAN and W. P. HALL¹.

Interest continues in weed control for tree nurseries. Weed removal has largely been a problem of hand removal or by control through mulching. Both methods are increasingly more expensive. Some progress in chemical weed control has been recently reported to this conference (1,2,4,5) and elsewhere in the literature (3,6).

Although a considerable reduction in production costs has been attributed to chemical weed control practices, the problem of herbicide selection still remains. Little of the research on nursery stock has been on forest tree species, and often the problem of new or resistant weed species is compounded by very young seedlings and/or herbicide-susceptible tree species. Winget (6), Mader (3) and Schneider (5) have indicated interest in simazine. Newer herbicides have become available but little or no data exist with regard to their performance on young forest tree nursery stock.

In view of the above it has become a most difficult problem for those making recommendations to suggest the proper material. The Vermont Department of Forests and Parks' nursery offered an opportunity to obtain such needed answers. Principle species of seedling stock were balsam fir, Abies balsamea; red pine, Pinus resinosa; white spruce, Picea glauca; larch, Larix decidua; white pine, Pinus strobus; Norway spruce, Picea abies; red spruce, Picea rubens; and white cedar, Thuja occidentalis.

Major weed species were purslane, Portulaca oleracea; sand spurry, Spergularia rubra; speedwell, Veronica peregrina var. xalapensis; also Oxalis, Polygonum, Digitaria, and Erigeron species.

Materials selected for this initial study included granular materials as well as wettable powders and liquids (Table 1). Applications to 2-0 stock were made on May 15, 1963 and to 1-0 stock on May 27. Liquids were applied uniformly in 500 ml. units with a sprinkling can; granulars with a sugar shaker. Sub-plots for each treatment-rate-age-species were 2 ft. x 2 ft. Weed ratings were made on three separate dates during the growing season and are presented below. Tree-injury was rated on two dates. Square-foot tree counts were made in the fall and are presented as percent-stand figures in Tables 7 and 8. Ratings were from 0-9 indicating a range from no weed control to no tree injury to 9 equal to complete weed absence or a completely dead tree stand. In the case of weeds, higher ratings are desirable; conversely for trees, the lower the rating the better the situation.

The effect of high and low rates of several herbicides (Table 2) on weeds was somewhat varied, in general fair, with the high rate a little better than the low. As different weed species predominated in the 1-0 beds as opposed to the 2-0 beds, these two groups are itemized separately. The poorer showing of low rates in the 2-0 beds was largely due to a majority of older or perennial species, while annuals and weed seedlings were dominant in the younger beds.

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TABLE 1 - HERBICIDES USED IN APPLICATIONS TO FOREST TREE NURSERY STOCK.

Material	Rate: lbs/A a.i.		Contributor
	Low	High	
Alanap-CIPC	(2.43+1.5)	(4.86+3.0)	Naugatuck
Alipur	2.5	5.0	Naugatuck
Casoron GA	3.0	5.0	Thompson-Hayward
SD 7961-G5	0.5	1.0	Shell Development
Simazine 4G	2.0	3.0	Geigy
Amizine	(1.51+1.53)	(1.02+3.06)	Amchem
Dacthal W75	4.5	9.0	Diamond Alkali
Sesone	0.9	1.8	Amchem
SD 7961-50F	0.5	1.0	Shell Development
Simazine 80F	2.0	3.0	Geigy
Dymid 80F	4.0	6.0	Eli Lilly
Treflan	4.0	6.0	Eli Lilly

TABLE 2 - EFFECT OF HERBICIDES ON WEEDS
Averages of all tree species and all dates.

Material & Rate	Average Ratings for: *					
	All 1-0 trees			All 2-0 trees		
	Low	High	Av.	Low	High	Av.
Alanap-CIPC	4.6	6.1	5.3	2.3	3.5	2.6
Alipur	4.7	6.8	5.7	1.2	5.0	2.1
Casoron	4.7	6.2	5.5	1.5	4.0	2.1
SD 7961-G5	3.9	4.7	4.3	2.7	5.0	3.2
Simazine 4G	4.3	5.0	4.6	2.3	6.0	3.2
Amizine	5.5	7.3	6.4	5.8	8.0	6.4
Dacthal	3.9	5.4	4.7	1.5	6.5	2.7
Sesone	3.4	4.5	3.9	3.2	5.5	3.7
SD 7961-50F	3.8	4.4	4.1	3.0	5.5	3.6
Simazine 80F	4.9	6.3	5.6	5.2	7.0	5.6
Dymid	3.5	4.7	4.1	3.8	6.0	4.4
Treflan	6.3	7.2	6.8	3.0	6.5	3.8
Unweeded ck.	1.1	1.3	1.2	0.8	0.0	0.6
Herbicide av.	4.4	5.7	-	2.9	5.7	-

* 0 = no control, 9 = best control.

Individual herbicide performance can be ascertained from Table 2. The mean figures for chemical performance averaged for various aged beds (Table 3) are perhaps more indicative of the relative weed controlling abilities of the several herbicides used. Tree species interactions are not presented as their influence was incidental to weed species present, except of course where high density of 2-0 stands precluded much of seedling weeds. The complete statistical evaluations of these data were not available at the time of stencil preparation; the means for treatments do exhibit significant differences at the 5% level. Of the more efficient herbicides, simazine, trifluralin, and the aminotriazole-simazine combination looked most promising. Granular simazine and Casoron, Dacthal, Alipur, and the Alanap-CIPC combination were intermediate to most weeds.

TABLE 3 -- EFFECTS OF HERBICIDES ON WEEDS
Averages of all age trees and all dates.

Material	Ratings for: Low Rates	Ratings for: High Rates	Mean*
Amizine	5.6	7.4	6.4
Treflan	5.4	7.1	6.2
Simazine 80%	5.0	6.4	5.6
Alipur	3.7	6.6	5.1
Alanap-CIPC	4.0	5.8	4.8
Casoron	3.9	6.0	4.8
Simazine 4G	3.8	5.1	4.4
Dacthal	3.3	5.5	4.3
Dymid	3.6	4.9	4.2
SD 7961-85	3.6	4.8	4.1
SD 7961-50%	3.6	4.5	4.0
Sesone	3.3	4.6	3.9
Unweeded ck.	1.0	1.1	1.1

* Mean differences significant at 5% level, and by Duncan's test.

In view of limited space, only mean effects of herbicides on tree species are reported here (Tables 4,5). Most notable is the relative susceptibility of 1-0 white pine and the relative resistance of 1-0 balsam and 1-0 red spruce to herbicide injury. The 2-0 plots of larch were relatively more susceptible, and the 2-0 balsam and 2-0 red pine were more resistant to the chemical treatments in general. Of the species present in both age groups, white pine and red pine showed increased resistance with increased age, balsam was about the same for both 1-0 and 2-0 response, while 2-0 larch was more sensitive than the 1-0 seedlings to herbicides. This variation in species-age response has been noted by others for other herbicides.

The summation of all-species, all-age response to the several herbicides in Table 6 shows a greater range of response of the 2-0 versus 1-0 trees. The greatest damage occurred from the use of Alipur, Casoron, and trifluralin, and possibly the Alanap-CIPC combination. The particular tree species not seriously affected can be ascertained from the lowest percent of stand figures in Tables 7 and 8. These four materials were equally most damaging to weeds (Table 3).

TABLE 4 - EFFECTS OF HERBICIDES ON 1-0 TREES*

Treatment	Ratings for Species #					
	E	D	B	C	G	A
Mean for low rate:	4.8	2.9	2.8	2.5	1.9	1.1
	E	B	C	D	G	A
Mean for high rate:	4.8	3.3	3.1	2.9	2.5	1.4
	E	B	D	C	G	A
Average:	4.8	3.2	3.0	2.8	2.2	1.3

* 0 = no injury, 9 = dead

Species code: A=Balsam, B=Cedar, C=Larch, D=Red Pine, E=White Pine, G=Red Spruce

TABLE 5 - EFFECTS OF HERBICIDES ON 2-0 TREES*

Treatment	Ratings for Species #					
	C	H	E	F	A	D
Mean for low rate:	1.6	1.5	1.1	0.7	0.4	0.0
Mean for high rate:	3.0	2.1	1.8	1.2	0.4	0.3
Average:	2.3	1.8	1.4	0.9	0.4	0.2

* 0 = no injury, 9 = dead

Species code: A = Balsam, C = Larch, D = Red Pine, E = White Pine,
F = Norway Spruce, H = White Spruce

TABLE 6 - EFFECTS OF HERBICIDES ON 2-0 TREES*

Treatments	Mean for Low Rate	Mean for High Rate	Average
Treflan	2.1	2.6	2.3
Alipur	1.4	2.8	2.1
Casoron	1.1	3.0	2.1
Alanap-CIPC	1.8	2.1	2.0
SD 7961-G5	1.4	2.0	1.7
Sesone	1.3	2.0	1.6
Amizine	0.5	1.8	1.1
Simazine 80W	0.7	1.0	0.8
Simazine 4G	0.5	1.0	0.8
SD 7961-50W	0.6	0.8	0.7
Dacthal	0.4	0.7	0.6
Dymid	0.2	0.7	0.4
Unweeded ck.	0.2	0.2	0.2

* 0 = no injury, 9 = dead

The lowest amount of tree injury was caused by use of Dymid, Dacthal, and Shell 7961-50W, a wettable powder (Table 6). Also, these compounds were least effective against weeds in most cases (Table 3). Although Shell 7961-50W, the granular formulation, and Sesone were fairly injurious to trees, they were of low effectiveness against weeds. The granular form of simazine caused slightly less tree injury than the wettable powder formulation, but significant statistically at only the low rates. This would seem to indicate only a difference in availability between the two forms. Granular simazine was intermediate in both weed and tree response. This was not the case with Simazine 80W nor Amizine. Although both these materials were intermediate with regard to tree injury, they were highly effective against weeds (Tables 2,3,6). Amizine appeared fairly safe on 1-0 balsam and white pine and on 2-0 balsam, red pine, white pine, and possibly 2-0 white spruce. Simazine 80W looked moderately safe on 1-0 balsam and white pine, and for 2-0 balsam, white pine, and white spruce.

These initial results showed an expected response in that herbicides with good weed control potential were in general among those more injurious to seed-

ling and year-old trees. Of those giving good weed control but with a low or negligible amount of tree injury, amizine and simazine would appear to merit further attention.

TABLE 7 - PERCENT SURVIVAL OF 1-0 TREES*

Treatment	A	B	C	D	E	G
Treflan	25	50	59	64	73	20
Dymid	100	50	84	94	59	100
Simazine 80%	60	0	53	28	50	10
SD 7961-50%	45	17	97	50	52	80
Sesone	60	33	36	50	20	66
Dacthal	60	33	100	44	46	82
Amizine	55	8	31	32	73	3
Simazine 4G	35	8	49	100	40	20
SD 7961-G5	40	100	36	99	80	40
Casoron	10	91	73	72	100	73
Alipur	5	0	20	40	33	10
Alanap-CIPC	25	66	11	24	50	10
Unweeded ck.	35	17	63	82	53	50

* Species code: A=Balsam, B=Cedar, C=Larch, D= Red Pine, E=White Pine, G=Red Spruce.

TABLE 8 - PERCENT SURVIVAL OF 2-0 TREES*

Treatment	A	C	D	E	F	H
Treflan	70	86	85	75	8	12
Dymid	93	89	57	38	76	46
Simazine 80%	90	100	28	100	20	60
SD 7961-50%	93	69	36	80	77	65
Sesone	96	57	78	61	76	56
Dacthal	100	74	57	88	81	54
Amizine	72	42	85	84	58	70
Simazine 4G	77	74	50	67	64	39
SD 7961-G5	82	52	71	84	99	65
Casoron	86	54	50	84	86	100
Alipur	86	33	100	50	52	88
Alanap-CIPC	91	64	57	55	79	65
Unweeded ck.	54	61	100	52	66	34

* Species code: A=Balsam, C=Larch, D=Red Pine, E=White Pine, F=Norway Spruce, G=White Spruce.

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EVALUATION OF HERBICIDES FOR GRASS CONTROL IN NEWLY PLANTED
CHRISTMAS TREESJohn F. Ahrens¹

Christmas tree plantations in the northeast usually are established on lands abandoned for other agricultural uses. These lands frequently are covered by hay or pasture grasses, weeds and brush. While the brush can be mechanically removed or chemically controlled, the herbaceous cover offers severe competition to young conifer transplants. The following report describes a preliminary experiment designed to investigate possibilities of reducing grass competition in Christmas tree plantings during the first year.

Materials and Methods

The field selected for the test had been pastured for many years. In recent years it was mowed annually in the fall to keep down the brush. Kentucky bluegrass (Poa pratensis) and redbud (Agrostis alba) were the dominant grass species but broomsedge (Andropogon virginicus) and Indian grass (Sorghastrum nutans (L.) Nash) also were scattered throughout the area. Paspalum pubescens, also a perennial grass, appeared in many of the plots during the season but was not found in the existing sod. The most frequent broadleaved weed was yellow toadflax (Linaria vulgaris), a perennial.

Graded three-year seedlings of white pine (Pinus strobus) and white spruce (Picea glauca) were planted by hand on April 23, 1963. The seedlings were spaced 2 feet apart in rows 6 feet wide, with thirteen of each species alternated in a row. The treatments were applied in 3-foot bands over the rows and were replicated three times in a randomized complete block design with three untreated plots included in each replicate.

Herbicides were applied on the existing sod on November 2, 1962, on April 23, 1963 just before planting, or on April 24 after planting. Spray treatments applied just before planting were allowed to dry 15 to 20 minutes before the trees were set. Spray applications were made with a calibrated knapsack sprayer, using 70 gallons of solution per acre. A precision auger-feed granular applicator was used to apply the granular treatments. The herbicide and formulations used are given in Table 1.

Observations and ratings of grass control were made at intervals through the season. Measurements of terminal growth

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Table 1. Herbicides and Formulations Used

<u>Chemical Name</u>	<u>Common Name</u>	<u>Formulation</u>	<u>Source</u>
2-chloro-4,6-bis (ethylamino)-s-triazine	simazine	80% wettable powder	Geigy Chemi- cal Co.
3-amino-1,2,4-triazole + 2-chloro-4-6-bis (ethylamino)-s-triazine	amitrole- simazine	15% amitrole+ 45% simazine	Amchem Products
2,2-dichloropropionic acid	dalapon	sodium salt	Dupont de Nemours
2,6-dichlorobenzonitrile	dichlobenil	4% granular	Thompson- Hayward Chemical Co.

were taken in August and survival counts were made in August and in the fall.

Results and Discussion

The herbicide treatments and their effects on weeds are shown in Table 2. Effects of the November treatments with simazine alone and in combination with amitrole and dalapon were not evident until the grass began to grow in the spring. No differences were observed on April 1, but on April 23 the differences were striking. Kill of the bluegrass and redbud sod was good to excellent with fall applications of simazine at 6 lbs. per acre alone, or 3 lbs. per acre in combination with amitrole or dalapon. The fall application of simazine at 3 lbs. per acre produced only fair kill of the sod on April 23, but this improved within a month.

The advantage of fall treatment could be seen in the ease of planting in the dead sod. It appeared that much less time and energy was required to plant in dead than in living sod. The dead strips of sod also clearly defined the planting areas.

By May 31, five weeks after planting, little difference could be seen between fall and spring application of the dalapon-simazine and amitrole-simazine combinations. However, post-planting applications of dichlobenil at 4 lbs. per acre and simazine at 6 lbs. per acre had not yet produced their maximum effects at that time.

The next observation, in August, revealed a striking contrast to earlier observations of excellent kill with most treatments. At this time yellow toadflax, broomsedge, Indian grass and Paspalum pubescens had so grown in the treated areas that the previous treatment effects were largely hidden. Ratings were made at this time of the percentage area covered by vegetation, and were later

Table 2. Weed Control in Pine and Spruce Transplants

Herbicide	Rate a.i. lbs./A	Time of application ¹	Ratings of kill of existing sod ²		Percentage control	
			Apr. 24	May 31	All weeds ³ Aug. 18	Redtop and bluegrass ⁴ Oct. 31
none	-	-	P	P	0	0
simazine, w.p.	3	Nov. 2	F	G	8	43
	6	Nov. 2	E	E	43	99
	6	Apr. 24 (Post)	-	G	67	96
amitrole+ simazine	1+3	Nov. 2	G	E	23	97
	1.5+4.5	Nov. 2	E	E	22	97
	2+6	Nov. 2	E	E	53	99
	1+3	Apr. 23 (Pre)	-	E	48	96
	2+6	Apr. 23 (Pre)	-	E	72	97
dalapon+ simazine	3+3	Nov. 2	E	E	15	96
	6+3	Nov. 2	E	E	37	93
	3+3	Apr. 23 (Pre)	-	E	40	97
dichlobenil, gr.	4	Apr. 24 (Post)	-	F	37	57
	8	Apr. 24 (Post)	-	G	67	90
L.S.D. p=.05					11	
p=.01					19	

¹Pre=preplanting; Post=postplanting.

²P=poor, F=fair, G=good, E=excellent.

³Based on percentage of area covered by vegetation.

⁴Based on percentage kill of only redtop and bluegrass.

converted to percentage control. As shown in Table 2, none of the herbicide treatments provided excellent control of the above species. However, the higher rates of dichlobenil, and simazine or simazine combinations were more effective in reducing the severity of the weed stands than the lower rates, and spring applications seemed to be more effective than fall applications. The higher rate of dalapon in the fall application of dalapon-simazine combinations appeared to be more effective than the lower rate against the summer invaders. Unfortunately, because of the variability of the weed populations, it was not possible to determine which species were controlled. Paspalum pubescens and yellow toad-flax, in particular, appeared to be encouraged by the openness of the treated strips and commonly were denser in treated than in adjacent untreated strips. All of these invading species were dormant when the herbicide treatments were applied and probably escaped severe injury.

After a few killing frosts the tops of yellow toadflax and Paspalum pubescens were killed back, and again the treated areas appeared relatively weed free. Ratings in the fall, also shown in Table 2 verified the kill of the bluegrass-redtop sod with most treatments. Simazine alone at 3 lbs. per acre in the fall, or dichlobenil at 4 lbs. per acre post-planting, was not sufficient to kill the sod completely, whereas simazine or dichlobenil at higher rates or simazine in combination with dalapon or amitrole provided excellent kill. The lower rates of the dalapon-simazine and amitrole-simazine combinations were as effective as the higher rates in killing the bluegrass and redtop sod and fall and spring applications were equally effective.

Effects of the herbicide treatments on mortality and growth of the conifer transplants are given in Table 3. Averaged over all

Table 3. Growth and Mortality in Pine and Spruce Transplants

Herbicide	Rate a.i. lbs./A	Time of application ¹	Percentage dead trees		Average growth in cm.	
			Pine	Spruce	Pine	Spruce
none	-	-	7	23	7.1	3.8
simazine, w.p.	3	Nov. 2	3	28	6.8	4.7
	6	Nov. 2	10	19	5.3a	4.0
	6	Apr. 24 (Post)	13	24	6.6	4.2
amitrole+ simazine	1+3	Nov. 2	10	40	6.3	3.8
	1.5+4.5	Nov. 2	24	17	5.9	3.6
	2+6	Nov. 2	13	42	6.2	4.4
	1+3	Apr. 23 (Pre)	5	25	7.3	3.8
	2+6	Apr. 23 (Pre)	8	19	5.8	3.7
dalapon+ simazine	3+3	Nov. 2	18	42	6.2	4.2
	6+3	Nov. 2	11	31	5.6	4.3
	3+3	Apr. 23 (Pre)	13	28	5.6	4.2
dichlobenil, gr.	4	Apr. 24 (Post)	8	50	7.3	3.5
	8	Apr. 24 (Post)	44b	53	4.6b	3.2

¹Pre=preplanting; Post=postplanting.

a - figure significantly less than controls at p=.05.

b - figures significantly less than controls at p=.01.

treatments, the white pine made 1 1/2 times as much growth and had less than half the mortality of the white spruce. Because of the small numbers of each species in the plots (13 of each), mortality was extremely variable and statistical analysis of the transformed data revealed no significant differences among the treatments on

spruce at the 5% probability level. Analysis of the pine data showed that dichlobenil at 8 lbs. per acre significantly increased the mortality. Although not statistically significant the injurious effects of dichlobenil were noted in the spruce data. Herbicides other than dichlobenil did not clearly affect survival in this test.

The growth data in Table 3 represent measurements on the surviving plants. No significant effects of treatments were found in the spruce data. However, simazine at 6 lbs. per acre in the fall and dichlobenil at 8 lbs. per acre in the spring significantly reduced growth of white pine in comparison to the controls, but because of variation between replicates, growth differences among herbicide treatments on white pine were not significant. The data suggest that 6 lbs. of simazine per acre may be too high a rate of application for newly planted white pine. Lower rates, in combination with amitrole or dalapon provided good control of grass and may prove to be less injurious to the trees. It is not yet clear whether fall or spring herbicide applications are less injurious.

It is of interest to note that the first season's growth and survival of pine and spruce transplants were not improved by the reduction in weed competition provided by the herbicide treatments. Rainfall was adequate in the spring and early summer of 1963, thus providing good conditions for tree survival in the grass sod and increasing the chances of herbicide injury by leaching to the root zones. Possibly the injury caused by herbicide treatments in this test counterbalanced the benefits of weed control. Further study is needed to determine this. The invasion of other species into sod killed by herbicides may also call for additional treatment.

Summary and Conclusion

An experiment was conducted to evaluate the effects of fall and spring herbicide applications on the kill of a grass sod and the growth and survival of newly planted seedlings of white pine and white spruce.

Herbicide treatments that effectively controlled the bluegrass-redtop sod included dichlobenil at 8 lbs. per acre after planting, simazine at 6 lbs. per acre in the fall or after planting, and combinations of simazine at 3 lbs. per acre plus amitrole at 1 lb. per acre or dalapon at 3 lbs. per acre, in the fall or before planting in the spring. All of these treatments failed to effectively control several other perennial grasses and broadleaved weeds during the summer. Higher rates of simazine, amitrole and dalapon in combinations did not improve kill of the bluegrass-redtop sod but did improve control of other perennial weeds. April applications were more effective than the November applications in controlling other perennial weeds.

Ease of spring planting was improved by killing the sod with herbicides in November. However, additional herbicide applications may be required to control those species invading or not killed by early season applications of herbicides.

Survival and growth of white spruce was not affected significantly by the herbicide treatments. However, in the white pine, simazine at 6 lbs. per acre in the fall appeared to decrease growth, and dichlobenil at 8 lbs. per acre after planting increased the mortality and decreased growth. Further study is needed to assess the value of grass control with herbicides during the planting year.

CONTROL OF RIPARIAN VEGETATION WITH PHENOXY HERBICIDES
AND THE EFFECT ON STREAMFLOW QUALITY

I.C. Reigner, W.E. Sopper, and R.R. Johnson¹

Although chemical control of vegetation along streambanks and reservoir shores has become an accepted procedure at a number of municipal water-supply systems in the Northeast, there is still some confusion and uncertainty about the safety of applying certain herbicides (5, 6).

The phenoxy group of chemicals--2,4-D and 2,4,5-T and related compounds--are more widely used than any other type of herbicide except on municipal watersheds. Although it is generally agreed they are not toxic to mammals, it is also agreed that phenols are a source of odor and taste contamination.

In water technology, "phenol" is a term used to describe a variety of ring-structured, substituted organic compounds. When chlorinated, these compounds form chlorophenols, which are said to have very low odor and taste thresholds (7), as low as 0.3 parts per billion (ppb.). Although there is practically no information in the literature about the safety of using these chemicals on public water supply drainage areas, to be on the safe side water-supply chemists have objected to them, presumably on the basis of theoretical considerations.

However, there have been several recent developments that may make the phenoxy herbicides more attractive to watershed managers. It has been known for some time that these chemicals are attacked and decomposed by soil bacteria. But it was hypothesized that the end products were other chlorophenols that had extremely low odor and taste thresholds. A recent study (7) has shown that, on the contrary, the end products of decomposition were carbon dioxide, inorganic chlorides, and water.

Second, the relatively new mistblower techniques apply much less material than the hydraulic sprays used heretofore. Used carefully, very little chemical would get into the water. In a large water supply system, the dilution would be so great that concentrations high enough to cause contamination would be almost impossible.

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Another factor in decreasing the possibility of contamination is the use of phenoxy herbicide formulations that do not contain oils. Emulsifiable acid formulations, for example, do not contain the aromatic oils that cause most of the contamination. The active ingredient has a much higher odor threshold than the aromatic oil solvents (7); that is, a much greater concentration of active ingredient is required to impart a phenolic odor.

A complicating factor in the problem of phenols in public water supplies is the occurrence of phenols from natural sources. Studies have been made at the Mellon Institute (4) to determine such contributions. Fermentation of oak leaves can result in the formation of phenolic materials. Oak leaves soaked in river water gave phenol levels of 1,250 ppb. in 10 days and 1,460 ppb. a month later. These phenols would probably be produced in dormant pools and would be flushed into streamflow after rainfall. As oak leaf decomposition is a constant process on both watersheds in this study, there must be a certain amount of phenol from this source most of the time. In laboratory tests for herbicides, these natural phenols might show up and confound the results.

In the light of these developments, a thorough field test of these chemicals was indicated. They are commonly used for brush control and stand improvement work by forest managers who would also like to use them for the control of riparian vegetation on watersheds. If they are a definite source of contamination, the facts should be made available. But if they can be used safely, or with certain precautions, this information should also be available in the literature.

STUDY METHODS

A study that we hope will provide the beginning of a fund of factual data on the subject was undertaken in July 1962. Two chemicals were selected for testing. One, an ester of 2,4,5-T (2,4,5-T, butoxy ethanol ester) was considered a representative formulation of the commercially available herbicides. In an oil-water emulsion, it was expected to give maximum contamination. The other, 2,4,5-T in the form of an emulsifiable acid with no oil carrier in the concentrate and diluted in water only, was expected to give the least possible contamination.

Treatment.--These chemicals were applied to separate but adjacent streams at two areas about 200 miles apart: (1) on two small headwater streams of the Newark Watershed, Newfoundland, N. J., and (2) on similar streams on the Standing Stone Experimental Forest near State College, Pa.

On each stream, a 1-acre plot was established about 1,000 feet long and 43 feet wide straddling the stream. The vegetation on the streambanks was sprayed with a mistblower, the operator walking in the stream and spraying a swath about 20 feet wide on one side only. The other side was sprayed in a return traverse of the stream. The same operator did the spraying on all four streams so that there would be the least possible variability of application. The two herbicide mixtures were as follows:

<u>Herbicide</u> ²	<u>Amount</u>	<u>Oil carrier</u>	<u>Water carrier</u>
2,4,5-T ester	½ gal. (2 lbs. ae)	1 gal.	8½ gal.
2,4,5-T acid	1 gal. (2 lbs. ae)	0	9 gal.

Only normal precautions, such as those used in an ordinary spray program, were taken to keep the chemical from getting into the water. Obviously it would be impossible to keep every bit of spray out of the stream, and we wanted to know if this amount had any measurable contaminating effect.

Streamflow data.--The degree of contamination that might result from spraying depends on the amount of dilution involved. This in turn is related to the discharge of the stream where treatment has taken place. Certainly, a large stream would dilute a fixed amount of herbicide more than would a tiny stream. Also, as downstream flow is larger than flow at the headwaters of a stream, the dilution occurring downstream will reduce any contamination found upstream. Therefore streamflow data were obtained at the sampling areas.

Flow at the time of treatment was very low, particularly in the small New Jersey streams; and the accuracy of measurement is only fair under such conditions. Nevertheless, the data are informative:

<u>Stream area</u>	<u>Streamflow at time of spraying</u>		<u>Streamflow after first large storm</u>	
	<u>cfs.</u> ³	<u>gpm.</u> ⁴	<u>cfs.</u> ³	<u>gpm.</u> ⁴
New Jersey:				
2,4,5-T ester stream	0.004	1.8	0.50	224
2,4,5 T acid stream	.010	4.5	.78	350
Downstream	.096	43.1	1.30	583
Pennsylvania:				
2,4,5-T ester stream	.038	17.0	.40	150
2,4,5-T acid stream	.080	35.9	.32	142
Downstream	--		.46	206

²The herbicides were furnished by Amchem Products, Inc. The first is sold under the trade name of Weedone Special Air Spray Formula and the second is an experimental formulation designated ACP M-654.

³Cubic feet per second.

⁴Gallons per minute.

Sampling the streamflow.--One-quart water samples were collected immediately downstream from each stretch as soon as the spray treatment was completed. Two samples were also taken at a control point at least 100 feet upstream from each stretch, at each time of sampling; and an additional sample was collected far downstream- about 1 mile. In both areas the downstream sampling point was below the juncture of the two treated streams. The samples were kept cool until they were tested.

A second group of samples was taken about 4 hours after treatment. Thereafter, sampling was done daily for the first week, and then twice a week for the next 3 weeks. Additional samples were taken after the first rainstorm following treatment, and also after the first large storm of 1.0 inch or larger.

Testing the samples for contamination.--Without going into the details of our search for a reliable chemical test for phenoxy herbicides, it may suffice to say that we failed to find any laboratory that could or would do it without prohibitively large samples. Therefore we accepted the conclusion of Robert Baker (2), who said, "Many devices have been developed but all fall short of human evaluation"; and we decided to use an odor panel. This method of testing has been criticized as being "unscientific" in this day and age. Perhaps it is, but the chemists do not agree on which phenols to test nor on how to test for them, although they do agree that the toxicological consideration is unimportant. The only possible contaminating effect of these herbicides is the undesirable medicinal odor or taste they may impart to drinking water. And this can best be detected and reported by a panel of humans.

The panel consisted of three young women, secretaries at the School of Forestry, The Pennsylvania State University, none of whom smoked. After a short period of training, the panel became extremely efficient.

The testing procedures followed, with some modification, the method tentatively approved by the American Society for Testing and Materials (1). The only important change was the use of stream water instead of odor free water as the control. This control water was taken from the upstream control points before it flowed through the treated stretch. As these raw stream waters usually had some odors, a comparison of the treated water with odor-free water would not have been a fair test of the treatment.

Another variation to the ASTM procedure was the use of samples of known concentration to orient the panel members. These samples were also used to determine the odor thresholds of the two herbicides.

The triangular test was used; two blanks or controls were presented to the panel member with each sample to be tested. The three samples were placed in front of the tester and she attempted to detect an herbicide odor in one of them. If she had no preference, the sample was considered to be under the odor threshold. The samples were judged in 500 ml. wide-mouth Erlenmeyer flasks with watch-glass covers, both of which had been thoroughly scrubbed with a brush and odorless detergent, and rinsed with odor-free water. The samples in their flasks were heated and maintained at 40° C. (104° F.) in a water bath. Testing was done in an empty well.

The various tests.--The first step in the testing routine was the orientation of the panelists. After the study was described in detail and their part in the study was explained, samples of the two herbicides were presented to them for odor orientation. The two odors were distinctly different: the 2,4,5-T ester had a strong petroleum smell, while the 2,4,5 T acid had a rather medicinal smell, somewhat but not exactly like a pure chlorophenol odor.

The first test evaluated the sensitivity of the panelists to known concentrations of both herbicides. These tests were made triangularly as described above, and the panelists were not informed as to the concentrations being tested. Two objectives were attained by these tests: (1) information on the concentrations needed to cause contamination, and (2) a calibration of the panel. As we now knew the concentrations the panel could detect, we could determine the approximate concentrations of contamination in streamflow samples.

The main tests involved the stream samples taken according to the schedule detailed earlier.

The effect of chlorination was questioned; it might increase the contamination by chlorination of phenols. On the other hand, since the herbicides were already chlorinated phenols, they might be oxidized and the contamination would disappear (3). Accordingly, a test was made by using known concentrations in tapwater. The samples were tested immediately after the chlorine was added and again several days later.

The last test involved the possible decomposition of the contaminant over a period of time. As the herbicides were known to decompose in soils, it was suspected that they would also decompose in raw stream water, which nearly always contains organic matter and bacteria. Known concentrations of both herbicides were introduced into samples of stream water taken at control points (above the treated areas). Half the samples were refrigerated at 35° F. while the other half were kept at room temperature, between 70° and 75° F. Tests were made every 2 weeks until the samples were aged 6 weeks.

RESULTS AND DISCUSSION

Calibration of the panel.--The results of the calibration tests were as follows:

1. 2,4,5 T ester.--All panelists could detect this herbicide at a concentration of 10 ppb. Panelist B could detect it at 5 ppb. only some of the time. These tests were made at recurrent intervals during the project and panelist B detected the herbicide at 5 ppb. enough times to conclude that the threshold odor for 2,4,5 T ester was in fact about 5 ppb.
2. 2,4,5-T acid.--As expected, this herbicide had a less potent odor than the former one. All panel members could detect it at 20 ppb. but only panelist B could detect it at 10 ppb. and then only occasionally. To allow the greatest tolerance, we concluded that the emulsifiable acid had a threshold odor of 10 ppb.

Both these odor thresholds were considerably higher (their contaminating strength was less) than the extreme figures found in the literature. We suspect they included a large safety factor. In addition, the temperature at which these tests were made provides another safety factor. Unflavored water at 40° C. (104° F.) is rarely ingested. Yet an odor is much more easily detected at 40° C. than at a more reasonable drinking-water temperature of 10° C. (50° F.).

The main tests. --Some contaminated water samples were found, but the contamination was not serious. It was found only in the samples taken immediately below the treated stretch, never in the downstream samples. It was found only in samples taken within 4 hours of treatment and then again (in one area only) after the first rain of 1 inch or more. By diluting the contaminated samples with control-point water until the odor could no longer be detected, we were able to evaluate the contamination in parts per billion:

	<u>Pennsylvania</u> <u>streams</u> (ppb.)	<u>New Jersey</u> <u>streams</u> (ppb.)
2,4,5-T ester:		
Immediately after spraying	40	40
4 hours later	20	20
Next 9 samples	neg.	neg.
After first large storm	10	neg.
2,4,5-T acid:		
Immediately after spraying	40	20
4 hours later	10	neg.
Next 9 samples	neg.	neg.
After first large storm	20	neg.
All downstream samples (both herbicides)	neg.	neg.

Effect of chlorination. --The addition of chlorine (Chlorox used as a water-purifying agent) did not accentuate the herbicide odors. Immediately after the addition of chlorine, the panelists could detect only the chlorine odor. Two days later the chlorine odor was gone, and panelist B could detect 2,4,5-T ester only half the time at 50 ppb. and not at all in lower concentrations. Panelist A could not detect 2,4,5 T ester in any of the samples. Neither panelist could detect the 2,4,5-T acid in chlorinated samples at 50 ppb. But for some unaccountable reason, panelist B could detect the herbicide half the time in samples containing 25 ppb.

Although this was not a highly controlled test, it seems quite likely that the effect of chlorine was to reduce the contamination instead of accentuate it.

Decomposition of the herbicides in raw stream water. -Samples of both herbicides were prepared in concentrations ranging from 5 ppb. to 10,000 ppb. (10 ppm.). As expected, the contaminating odors decreased with the passage of time. At the end of 6 weeks, the panelists were able to detect odors only in the higher concentrations. The concentrations at which an odor could be detected were as follows:

Sample	Weeks after preparation			
	0 (ppb.)	2	4 (ppb.)	6 (ppb.)
2,4,5-T ester at 38° F.	5	5? ⁵	10?	40
2,4,5-T ester at 70-75° F.	5	5?	20?	40?
2,4,5-T acid at 38° F.	20	20	80	10,000
2,4,5-T acid at 70-75° F.	20	20	80?	10,000

It appears that the oil does not decompose as rapidly as the chloro phenol. No significant difference between the two storage temperatures was apparent.

Effect of herbicide on vegetation.--All the treated areas were examined in August 1963, near the end of the first growing season after treatment. Sample plots were established and tallies were made by species, diameter class, and percent of stem kill.

All of the streamside vegetation was brushy; density of riparian vegetation under 4.0 inches dbh. ranged from 5,600 to 11,520 stems per acre. The Pennsylvania streams had a somewhat larger percentage of stems under 0.5 inch in diameter at a height of 1 foot. On all plots, less than 4 percent of the stems were larger than 2.5 inches dbh. The condition of all vegetation less than 4 inches dbh. was as follows:

<u>Stream area</u>	<u>Stems damaged</u> (percent)	<u>Stems dead</u> (percent)
2,4,5-T ester Pennsylvania	17	81
2,4,5-T ester-New Jersey	23	70
2,4,5-T acid-Pennsylvania	21	78
2,4,5-T acid-New Jersey	32	58

The proportion of totally dead stems in Pennsylvania was somewhat higher than that in New Jersey, but this may be related to the larger proportion of very small stems. Considering only the totally dead stems, the 2,4,5-T ester appears to have done a better job than the emulsifiable acid, as expected on the basis of prior experience. But when the stems are added to the totally dead stems, the differences are probably not significant.

⁵? Indicates the panelist B could detect these concentrations only half the time.

It is certain that the brushy riparian vegetation has suffered a severe setback. A subsequent treatment on the same area in 3 to 5 years should eliminate most of the remaining stems. After several treatments, a heavy growth of grass and weeds may be expected and the reinvasion of woody plants should be very slow.

CONCLUSIONS

Recent findings and developments have insured numerous safeguards or safety factors for the use of phenoxy herbicides on municipal watersheds. It is now known that the herbicides decompose to harmless end products in soil and in water. Thus, even if the herbicide were introduced directly into the stream or reservoir, storage alone would eliminate much of its contaminating action. Chlorination--and all public water supplies from surface water are chlorinated--will also help to eliminate the taste and odor of phenolic compounds.

The field test described here is good evidence that very little contamination occurs even in the stream where treatment has taken place, and that downstream areas receive no contamination. Another safeguard is the use of 2,4,5-T acid rather than the more common ester. Although the former is perhaps a little less effective than the latter, a successful deadening of the riparian vegetation may be expected from either formulation.

Considering all these safeguards, it appears perfectly safe to conclude that, if mist-sprayed with normal precautions, phenoxy herbicides can be used on municipal watersheds without creating any water contamination.

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SOME FACTORS AFFECTING HARDWOOD CONTROL
WITH MISTBLOWER APPLICATIONS OF 2,4,5-T

Thomas W. McConkey

When white pine is grown and regenerated under a shelterwood system of silviculture, mistblower applications of 2,4,5-T have proved to be an effective way to control unwanted small hardwood trees and brush. Such treatments are fairly simple to use because the hardwoods are more sensitive to 2,4,5-T than the pines, and the chemical thus acts selectively.

However, when the species that we wish to favor is a sensitive hardwood, selective killing of unwanted vegetation is impossible with broadcast applications of the chemical. This problem arises in the management of many hardwood species. In the Northeast, we encounter this problem particularly in managing paper birch--a species highly sensitive to 2,4,5-T. A pertinent question is the extent to which desired results might be achieved by more refined and carefully controlled techniques of application.

Although the hardwoods generally are sensitive to 2,4,5-T, the results from mistblower treatments often are erratic, even with the highly sensitive birch. On the premise that these erratic results reflect unrecognized variations in methods and timing, a preliminary study was carried out to try to determine some of the underlying causes.

THE STUDY

The study here reported was established in 1962 on the Massabesic Experimental Forest in southwestern Maine. Four of the possible reasons for erratic results were investigated: date of application, thoroughness of coverage, rate of application, and carrier (No. 2 fuel oil versus water). Time of application and kind of carrier are also known to influence kill.¹ And in our local work with mistblowers, there have been numerous indications that care in application is important.

A young hardwood stand, composed predominantly of 14-year-old paper birch, was most readily available for the study. Stocking density ranged from 8,000 to 31,000 stems per acre and averaged 16,500 stems. Tree heights ranged from 5 to 20 feet. Ninety-six small plots, measuring about 10 x 10 feet each, were established. Fifteen sample trees were tagged on each plot for future observations of kill or damage resulting from the treatments.

¹Woods, Frank W. Control of woody weeds: some physiological aspects. U.S. Forest Serv. South. Forest Expt. Sta., Occas. Paper 143, 50 pp., 1955.

Six dates in 1962 were selected for the applications: May 7, when leaves were about half grown; June 1 and 15; July 2 and 16; and August 15. Two degrees of coverage were devised to test care in application. These, based on average height of codominant stems, were: ground to 3/4 height, and 1/4 to full height.

Rates of application were desired that would permit maximum differentiation of treatment efficacy among the other variables. This required selection of at least one borderline rate of application that would not always be effective. It was known that 1/2 pound acid equivalent of 2,4,5-T per acre will kill birch, at least under some conditions. This rate and an expected less damaging rate of 1/4 pound acid per acre were selected. These amounts of acid equivalent were applied in both No. 2 fuel oil and in water at the rate of 10 gallons per acre.

The above variables add up to 48 treatment combinations. Each treatment was applied to 2 plots.

RESULTS

The first tally of results, made in 1963, was of the 15 tagged trees on each plot. A summary of these data showed a difference between the two kinds of coverage but no clear-cut difference between rates of application. To get a better estimate of certain of the treatment effects, total stem tallies were made on the plots treated at the 1/2 pound rate in oil carrier for both kinds of coverage, and on those treated at the 1/4 pound rate in oil carrier at the 1/4 to full height coverage. Even in these total tallies no definite difference in kill between the two rates of application was apparent.

Date of Application

Practically no kill or damage resulted from the May 7 treatments, and the data for this date are not considered further. For the 1/4 to full height coverage at both rates of application in oil carrier, best results were obtained in the July 2 treatment, where 83 percent of the stems were killed. However, the results for mid-June, early July, and mid-July were essentially the same, ranging from 79 to 83 percent stem kill. The early June treatments were somewhat less effective, and the mid-August treatments were poorest (exclusive of May 7), with a kill of 48 percent (table 1).

Degree of Coverage

The data for the 1/2-pound rate in oil for all application dates (except May 7) show the relationship of degree of coverage to stem kill. When the trees of these plots are segregated by dominance classes, only 25 percent of the dominants and codominants were killed by the ground to 3/4 height treatment, whereas 71 percent of the intermediates and 89 percent of the overtopped trees were killed (table 2).

Table 1.--Relation of date of application to kill
of paper birch stems

(Based on total tallies of all plots treated at $\frac{1}{4}$ to full height with 2,4,5-T in oil)

Date of treatment	Dead		Severely damaged		Little or no damage		Total
	No.	%	No.	%	No.	%	
6/1/62	173	73	13	5	52	22	238
6/15/62	186	81	17	8	26	11	229
7/2/62	202	83	9	4	32	13	243
7/16/62	168	79	13	6	33	15	214
8/15/62	116	48	40	17	83	35	239
Average	--	73	--	8	--	19	--

Since, in this context, the designation "3/4 height" means 3/4 the height of codominants, these results are about what might be expected, because the crowns of the dominants and codominants were mostly above the zone of spray application in this treatment. The intermediate and over topped trees, being shorter, had larger proportions of their crowns in the spray zone and the kills consequently were much higher.

For the 1/4 to full height treatment, differences in kill among dominance classes were relatively small (table 2) because most of the crowns of all classes were in the spray zone. The overtopped class here showed the least kill- 72 percent. The reason more trees in this class survived probably lies in the fact that some of them were too short to reach into the spray zone.

The results for the two degrees of coverage generally confirm the principle that thorough coverage is required for good kills, and that, even in such sensitive species as paper birch, many trees will survive light or partial contact with the herbicide.

Carrier

Kills and damage among the tagged trees on plots treated at the 1/2-pound rate at 1/4 to full height illustrate the difference between oil and water carriers. Kills were consistently better with the oil carrier. Average kill for the 5 treatment dates was 56 percent with oil, as compared to 35 percent with water (table 3).

Table 2.--Relation of degree of coverage to kill of paper birch stems(Based on total tallies for all plots treated at the $\frac{1}{2}$ lb. rate in oil)

Crown class of trees	Degree of coverage	Dead		Severely damaged		Little or no damage		Total
		No.	%	No.	%	No.	%	
Dominant and Codominant	Ground to 3/4 height	28	25	9	8	74	67	111
	1/4 to full height	89	74	15	12	17	14	121
Inter- mediate	Ground to 3/4 height	67	71	6	6	22	23	95
	1/4 to full height	140	80	16	9	20	11	176
Overtopped	Ground to 3/4 height	248	89	8	3	23	8	279
	1/4 to full height	201	72	14	5	63	23	278

FOLLOW-UP TEST, 1963

The differences observed between the two degrees of coverage in the 1962 experiments, particularly the high survival among dominants and codominants in the ground to 3/4 height treatments, suggested that mist blower applications of 2,4,5-T could be used to reduce understory growth in young hardwood stands without seriously damaging the overstory, even in stands of species as sensitive as paper birch. This possibility was confirmed by a mistblower application of 1/2 pound acid equivalent in 10 gallons of carrier at the ground to 3/4 height level on a 1-acre plot of sapling paper birch on July 18, 1963.

Table 3.--Relation of carrier to kill of paper birch stems

(Based on sample trees on all plots treated at $\frac{1}{2}$ lb. rate, $\frac{1}{4}$ to full height coverage)

Date of treatment	Dead		Severely damaged		Little or no damage	
	Oil	Water	Oil	Water	Oil	Water
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
6/1/62	67	17	30	17	3	66
6/15/62	67	33	30	30	3	37
7/2/62	57	43	30	27	13	30
7/16/62	43	53	30	17	27	30
8/15/62	47	26	40	37	13	37
Average	56	35	32	25	12	40

It had been observed in 1962 that, under certain weather conditions, the spray in the ground to $\frac{3}{4}$ height treatments would drift upward with air currents and kill or damage some of the taller trees. An invert emulsion was used in 1963 to lessen this hazard. To get an emulsion thin enough to use in a mistblower, a detergent was added to the water, and the proportion of oil was increased. The emulsion used in the 1-acre test was prepared as follows: 1 quart of invert formulation ($\frac{1}{2}$ pound acid) was added to $2\frac{1}{2}$ gallons of oil, and about 4 ounces of detergent were added to $7\frac{1}{2}$ gallons of water; then these components were mixed together to form the emulsion.² The viscosity of this emulsion was comparable to that of SAE No. 20 or No. 30 motor oil.

With the invert emulsion, excellent control of application at the specified level was possible, and a satisfactory reduction of the understory was achieved with practically no damage to the overstory.

²This procedure does not always produce a good emulsion, nor is the emulsion always stable; but it usually works satisfactorily. Anyone considering use of such emulsions in mistblowers on more than a small experimental scale should contact manufacturers for their recommendations.

SUMMARY

In a study of some of the possible causes of variable results in mistblower treatments of hardwoods, 2,4,5-T at the low rates of 1/4 and 1/2 pound acid equivalent per acre were variously applied in a sapling stand of paper birch. The treatments were most effective during a 4- to 6-week period beginning in early June. Treatments in mid-August were little more than half as effective as treatments in early July. Kills were considerably better with oil carrier than with water carrier. Complete and thorough coverage of the tree crowns is required for good kills. In a supplemental test using invert emulsion to minimize spray drift, the results indicate that, even in young stands of species as sensitive as paper birch, understories can be satisfactorily reduced by carefully directed mistblower applications without damaging the overstory.

FRILLING AND INJECTING METHODS FOR HARDWOOD CONTROL
IN WESTERN VIRGINIA

John P. Sterrett and W. E. Chappell¹

The removal of undesirable hardwood trees for timber stand improvement in the southern Appalachian Mountains of Virginia is a major silvicultural problem. Effective, economical herbicidal methods that will control undesirable oaks, hickories and maple are much in demand. Frilling and injecting techniques are being used but more information is needed regarding seasons, spacing of incisions and herbicidal concentrations for specific species.

Peevy, 1961, in Louisiana, recommended the use of 12 to 40 pounds of esters of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) aehg of diesel oil in injectors with spacings from $\frac{1}{2}$ to 2 inches depending upon species and size. Little, 1963, recommended using ester formulations of 2,4,5-T in injectors at 80 pounds aehg in oil for killing New Jersey and eastern Maryland hardwoods. Starr, 1963, found that concentrated forms of the amine salt of either 2,4,5-T or 2,4-D controlled hardwood species in Mississippi satisfactorily with 2-inch injector spacings. Peevy, 1963, also found undiluted 2,4-D amine was effective in controlling Louisiana hardwoods.

The terrain and environment are somewhat different in western Virginia from the above areas. Therefore an experiment, described herein, was designed to determine the most effective herbicidal concentrations, methods and seasons to kill several undesirable hardwoods. Results of another experiment in which undiluted herbicides were applied in frills will be available at the end of the 1964 growing season.

Procedure

Four injector and two frill treatments were applied to four species of hardwood trees ranging from 4 to 10 inches d.b.h.: scarlet oak (Quercus coccinea), white oak (Q. alba), chestnut oak (Q. prinus), and hickory (Carya spp.). These treatments were applied in February, June, and October, 1962, by a U. S. Forest Service timber stand improvement crew. The October treatments will not be evaluated until the end of the 1964 growing season.

Each treatment was replicated four times in a randomized block design on 1/10-acre plots averaging 40 trees per plot. Evaluations were made on the following basis:

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1. Top killed trees -- completely defoliated trees with or without sprouts.
2. Top killed trees with sprouts -- top killed trees with at least one sprout.

The percentage of top killed trees was determined by dividing the number of dead trees with dead tops counted at the end of the second growing season after treatment by the total number treated and multiplying by 100. The percentage of top killed trees with sprouts was determined by dividing the number of completely defoliated trees with sprouts counted at the end of the second growing season after treatment by the total number of top killed trees and multiplying by 100.

Butoxy ethanol ester of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) in No. 2 fuel oil was used in each of the following treatments:

1. 20 lb. injector (girdle) -- 20 lb of 2,4,5-T aehg No. 2 fuel oil was applied with a Cran-jector. The base of each tree was completely girdled with overlapping incisions.
2. 40 lb. injector (girdle) -- 40 lb of 2,4,5-T aehg No. 2 fuel oil was applied similarly to treatment 1.
3. 20 lb. injector (spaced 2") -- 20 lb of 2,4,5-T aehg No. 2 fuel oil was applied with a Cran-jector. The incisions were spaced 2 inches apart (edge-to-edge) at the base of each tree.
4. 40 lb. injector (spaced 2") -- 40 lb of 2,4,5-T aehg No. 2 fuel oil was applied similarly to treatment 3.
5. 8 lb. frill (girdle) -- 8 lb of 2,4,5-T aehg No. 2 fuel oil was applied in overlapping ax frills waist high on the trunk of each tree.
6. 16 lb. frill (girdle) -- 16 lb of 2,4,5-T aehg No. 2 fuel oil was applied similarly to treatment 5.

Each injector incision was filled with the herbicidal mixture (approximately 5 ml per incision). The ax frills were thoroughly soaked with the herbicidal mixture to the point of run-off (approximately 25 ml per inch d.b.h.).

Results and Discussion

The data were analyzed by the analysis of variance method. The results on white oak, scarlet oak, chestnut oak and hickory are summarized in Table 1. Chestnut oak and hickory were not uniformly distributed throughout the experimental area, so it was necessary to include them with the white and scarlet oaks. There were no significant differences in the percentage of top kill among the injector (girdle) and frill (girdle) treatments made in February and June (Table 1). The percentage of tops killed resulting from the injector (spaced 2") methods was significantly less than any of the girdle treatments and were more effective when made in June than in February. The 40-lb rate applied in June was the most effective spacing treatment. Sprouting from both frill treatments was significantly higher than that from any of the injector treatments. The 8-lb frill treatment in June and February was as effective as the 16-lb frill treatment on all species and the results of the 20-lb injector treatments (both girdled and spaced) made in February were equal to their respective 40-lb injector treatments.

The results on white oak are summarized in Table 2 and those on scarlet oak in Table 3. These results on individual species are similar to those found in Table 1 with the following exception. White oak sprouting following the June treatment was significantly higher from the 20-lb injector (girdle) treatment than from the 40-lb injector (girdle) application (Table 2).

The injector method of treatment controlled sprouting more effectively than the frill method, apparently because the injector incisions were made closer to the root collar whereas the frills were cut several feet higher on the trunk. The spaced injector treatments may show more effect by the end of the third growing season, because at the time of evaluation there was some defoliation on all of the species.

Summary and Conclusions

Four injector and two frill treatments were applied on white oak, scarlet oak, chestnut oak and hickory in February, June, and October, 1962. The October treatments have not been evaluated. Different concentrations of butoxy ethanol ester of 2,4,5-T in No. 2 fuel oil were applied with the Cran-jector and in ax frills.

Excellent top kills on all species tested resulted from both the frill and injector girdle treatments, but the injector treatment controlled sprouting more effectively. The 8-lb rate of 2,4,5-T in No. 2 fuel oil applied by the frill method was as effective as the 16-lb frill treatment when made in February and June. In February, the results of the 20-lb injector treatments with 2,4,5-T in No. 2 fuel oil (both girdled and spaced 2") were equal to their respective 40-lb injector treatments. White oak sprouting from June treatments was higher from the 20-lb injector (girdle) treatment than from the 40-lb injector (girdle) treatment. The percentage of top kill resulting from both

injector (spaced 2") methods was much lower than that from any girdle treatment but the injector (spaced 2") method was more effective when made in June than in February.

The results obtained in this work indicate that 20 lb of 2,4,5-T aehg in No. 2 fuel oil applied by the Cran-jector method in the winter will give an effective top and sprout kill on the species tested. Based on these experiments, incisions should completely girdle the base of the tree. White oak sprouting was more effectively controlled in June with the 40-lb injector girdle treatment than with the 20-lb injector girdle rate. If sprouting is not objectionable, 8 lb of 2,4,5-T aehg in No. 2 fuel oil applied in frills will give an excellent top kill on all of the species tested.

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Table 1. Results of injector and frill treatments on 4- to 10-inch d.b.h. white oak, scarlet oak, chestnut oak and hickory using butoxy ethanol ester of 2,4,5-T at the listed aehg in No. 2 fuel oil

Treatments with 2,4,5-T	Top killed trees, %	Top killed trees with sprouts, %
February, 1962		
20 lb, injector (girdle)	88 a <u>1/</u>	19 a <u>1/</u>
40 lb, injector (girdle)	91 a	17 a
20 lb, injector (spaced 2")	29 d	30 a
40 lb, injector (spaced 2")	24 d	18 a
8 lb, frill (girdle)	100 a	78 b
16 lb, frill (girdle)	100 a	64 b
June, 1962		
20 lb, injector (girdle)	86 a	40 a
40 lb, injector (girdle)	100 a	13 a
20 lb, injector (spaced 2")	55 c	36 a
40 lb, injector (spaced 2")	70 b	23 a
8 lb, frill (girdle)	98 a	75 b
16 lb, frill (girdle)	97 a	70 b

1/ Any two treatments in a vertical column not having the same letter are significantly different.

Table 2. Results of injector and frill treatments on 4- to 10-inch d.b.h. white oak using butoxy ethanol ester of 2,4,5-T at the listed aehg in No. 2 fuel oil

Treatments with 2,4,5-T	Top killed trees, %	Top killed trees with sprouts, %
February, 1962		
20 lb, injector (girdle)	100 a ^{1/}	18 ab ^{1/}
40 lb, injector (girdle)	97 a	6 a
20 lb, injector (spaced 2")	45 d	11 a
40 lb, injector (spaced 2")	31 d	8 a
8 lb, frill (girdle)	100 a	88 c
16 lb, frill (girdle)	100 a	84 c
June, 1962		
20 lb, injector (girdle)	89 ab	39 b
40 lb, injector (girdle)	100 a	8 a
20 lb, injector (spaced 2")	66 c	20 ab
40 lb, injector (spaced 2")	79 bc	22 ab
8 lb, frill (girdle)	100 a	87 c
16 lb, frill (girdle)	98 a	84 c

^{1/} Any two treatments in a vertical column not having the same letter are significantly different.

Table 3. Results of injector and frill treatments on 4- to 10-inch d.b.h. scarlet oak using butoxy ethanol ester of 2,4,5-T at the listed aehg in No. 2 fuel oil

Treatments with 2,4,5-T	Top killed trees, %	Top killed trees with sprouts, %

February, 1962		
20 lb, injector (girdle)	83 a <u>1/</u>	12 a <u>1/</u>
40 lb, injector (girdle)	90 a	21 ab
20 lb, injector (spaced 2")	22 c	47 bcd
40 lb, injector (spaced 2")	18 c	30 ab
8 lb, frill (girdle)	100 a	67 de
16 lb, frill (girdle)	100 a	51 cde
June, 1962		
20 lb, injector (girdle)	82 a	32 abc
40 lb, injector (girdle)	100 a	5 a
20 lb, injector (spaced 2")	52 b	55 abc
40 lb, injector (spaced 2")	63 b	17 ab
8 lb, frill (girdle)	98 a	75 e
16 lb, frill (girdle)	95 a	64 e

1/ Any two treatments in a vertical column not having the same letter are significantly different.

1963 RESULTS FROM INJECTOR TREATMENTS
OF NEW JERSEY AND MARYLAND HARDWOODS

S. Little and R. H. Fenton¹

Tree injectors are efficient tools for applying limited amounts of herbicides to the stems of individual trees, but the efficacy of injector treatment varies with several factors. Species differ in susceptibility, and so do stems of unequal vigor within species. Formulation, concentration, and amount of herbicide, as well as season and spacing of cuts, all affect rapidity and amount of kill.

To provide local guides to successful techniques, a study of injector treatments was started in New Jersey and Maryland in 1961 by the North eastern Forest Experiment Station in cooperation with the New Jersey Bureau of Forestry and the Maryland Department of Forests and Parks. First-year results were reported before this Conference last year.² This paper summarizes the second year results from that study and first- and second-year results from other tests that supplement the major study.

STUDY METHODS

In the 1961 study major emphasis was placed on: (1) two materials-- a 2,4,5-T ester used in an oil carrier and a 2,4,5-T amine used in a water carrier;³ (2) three concentrations of each material--40, 80, and 160 pounds aehg. (acid equivalent per 100 gallons); (3) four seasons or months of treatment--May, August, October, and January; and (4) three stand conditions--those typical of eastern Maryland, of northern New Jersey, and of upland sites in the Pine Region of southern New Jersey.

Species composition of the stands differed somewhat among these localities. In eastern Maryland the more common species were red maple, several oaks (water, white, swamp chestnut, black, southern red, and willow oaks), sweetgum, holly, blackgum, and sweetbay. In northern New Jersey the more common ones were dogwood, red and sugar maples, and witch-hazel; several others, such as sweet birch, white ash, black cherry, beech, basswood, northern red and chestnut oaks, hornbeam, and hophornbeam were present in less abundance. In southern New Jersey nearly all of the treated stems were chestnut oaks, black oaks, or white oaks.

¹Research Foresters, Northeastern Forest Experiment Station, Forest Service, U.S. Dept. Agriculture.

²Little, S. Injector treatments for killing New Jersey and eastern Maryland hardwoods. Northeast. Weed Control Conf. Proc. 17: 494-501.

³These were furnished by Amchem Products, Inc., and are sold under the trade names of Trinoxol and Weedar Amine 2,4,5-T. Both contain 4 pounds acid equivalent per gallon.

In each locality a 0.2- or 0.4-acre plot was established for each of the 24 combinations of material, concentration, and season. In all treatments, an application of 2 ml. of solution per cut in cuts spaced about 1 inch apart was specified, but in some instances less than 2 ml. was actually applied. Injectors used were the locally made Cran-jectors. Number of stems per treatment averaged about 110 in North and South Jersey and about 200 on the Maryland Eastern Shore.

In southern New Jersey, in the same general stand referred to above, 160 black oaks were tagged and given measured dosages of undiluted materials in cuts made with an injector. In each season 40 trees were treated --20 with each of the two materials used in the main study. Ten of each 20 trees received 0.5 ml. per cut, and 10 received 1.0 ml. per cut. Chemicals were applied with a graduated syringe.

The 1961 study was supplemented by treatments in many other stands, especially in New Jersey, during 1961 and 1962. For 11 of these stands, plus some smaller trials, data on date and type of treatment and on effects by species are available.

RESULTS

DILUTED MATERIALS

Kills obtained in the initial study through the second year are summarized in table 1. Although the higher concentrations tended to be somewhat more effective in most seasons for both materials, the data showed no strongly consistent trends in relation to season, material, or concentration.

The lack of a consistent trend and the failure to obtain complete kills in most of the treatments are attributed to faulty techniques. At least part of the reason for the poor techniques was that 10 different men, some of whom were rather careless workmen, helped in making these treatments.

The conclusion that poor technique was responsible for much of the poor kill was supported by a close examination of the South Jersey plots: nearly all the stems still living in 1963 had been poorly treated. Either the spaces between cuts were greater than the specified inch, or the cuts were so shallow that they had not penetrated through the bark. In some cases the spacing was satisfactory but only the center inch of the 3-inch cut had penetrated the bark, and there still were 2- or 3-inch spaces left in which life bars--strips of living tissue--kept the crown more or less alive. Only an occasional stem that appeared to have been properly treated was still alive.

The same story prevailed in the other localities in plots that were closely examined. For example, in the October and January treatments on the Eastern Shore, only the plot treated with amine at 40 pounds aeshg. in October had more than 5 stems still alive among those that had apparently been properly treated. Of the 12 stems still alive on this plot despite apparently proper treatment, 11 were either maples or hollies.

Table 1.--Second-year mortality of treated stems,
by locality and treatment

Locality	Treatment	Stems killed ¹ by treatment in--				
		May	Aug	Oct	Jan	
	<u>Lbs.</u> <u>aehg.</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	
Eastern Shore	Amine	40	69	60	86	69
		80	64	63	81	57
		160	79	80	95	69
	Ester	40	68	60	59	47
		80	73	77	85	70
		160	87	89	90	98
South Jersey	Amine	40	66	75	62	59
		80	87	83	81	69
		160	98	92	82	70
	Ester	40	80	87	66	35
		80	82	93	79	68
		160	93	95	82	58
North Jersey	Amine	40	56	75	58	40
		80	33	92	70	31
		160	60	65	64	47
	Ester	40	39	77	60	55
		80	57	81	54	76
		160	62	91	79	68

¹Includes both stems completely killed and those sprouting from the base.

The 2-year results thus indicate that, within the ranges of variables covered by these tests, treatment technique is far more important than materials or concentrations. The 1-inch spacing called for in the study was generally effective if the gaps conformed closely to this specification, if the cuts penetrated full width into the wood, and if the specified 2 ml. of solution was delivered in each cut. However, because the ordinary run of woods labor cannot be depended on to follow these specifications closely, especially with respect to the spacing between effective cuts into the wood, and secondly, because some trees of the more resistant species survived even after apparently proper treatment, we believe that complete frills should be specified as standard procedure. This will not result in all frills being absolutely complete, but it should reduce the number and width of gaps to such a degree that very few trees would survive. In essentially complete frills, there would seem to be no reason to use concentrations of chemical greater than 80 pounds aehg., or to apply more than about 1.5 ml. of solution per cut.

Prescriptions based upon differences in species susceptibility could be developed and undoubtedly could be applied successfully by careful, intelligent workmen. Well made cuts 1 inch apart would be quite adequate for many species, and even wider spacing would suffice on such sensitive species as sassafras. For the more resistant ones like the maples and holly, complete frills would be advisable to ensure a high percentage of prompt kills. But in view of the type of labor generally available for woods work, prescriptions of this sort would not be practicable. One simple, standard specification of complete frills for all species seems the more realistic approach.

Actually, the amount of extra time and material required for complete frills would not be excessive. For example, on a stem 9 inches in diameter at the frill, seven 3-inch cuts would be required at 1 inch spacing, and 9 such cuts would be required for a complete frill.

Some of the stems encountered in the usual wooded areas are difficult to frill completely. Trees with very thick bark, such as large chestnut oaks, offer considerable resistance to the injector, but with care and effort they can be successfully treated. Far more difficult to treat are the occasional deformed trees or trees in multiple stem situations having areas of live bark that cannot be reached effectively with the injector blade. These include: (1) trees with an ingrown hollow or catface at the base; (2) dense sprout clumps; (3) paired trees, of either the same or different species, growing in contact or near contact with each other at their bases; and (4) trees leaning to such a degree that herbicide cannot be effectively injected by gravity flow on the underside.

Our only suggestions for treating such problem stems are to make as nearly complete frills as humanly possible, and to apply somewhat more herbicide than usual. For instance, on stems with catfaces, make the usual low complete frill except for the catface, then treat above the catface if possible, and overlap the lower and higher series of cuts so that the development of life bars is unlikely. An overlap equal to half the vertical distance between the two series of cuts should be sufficient.

Low frills are important to reduce sprouting. In our observations, when cuts have been made within 6 inches of the ground, usually less than 5 percent of the stems have sprouted. However, where cuts have been generally higher, with many of them 12 to 18 inches above ground, up to 45 percent of the treated stems in certain stands have sprouted.

The various species in the treated areas have shown appreciable differences in susceptibility to injector treatments. If properly treated, many species can be expected to die within a year. These include all the oak species, ash, gray birch, black cherry, dogwood, hornbeam, hophornbeam, black locust, sassafras, serviceberry, sweetbay, sweetgum, witchhazel, and willow. Among the more resistant species, which typically exhibit distress within 1 year and usually die within 2 years, are sweet birch, blackgum, hickory, and holly. Red maple is only slightly more resistant than this second group, but sugar maple is far more resistant. In three North Jersey stands, the crown reduction and mortality of sugar maple during the first 2 years were only about a third as much as for red maple.

Of course, perceptible differences exist within the above groups. Chestnut oak and water oak are usually somewhat more resistant than the other oaks, and sweet birch and holly are somewhat more resistant than blackgum. In some areas dogwood seems to fit better in the second (moderately resistant) group than in the first group.

Size and vigor of stems also affect susceptibility. Within a given species in the same stand, the larger stems usually show less response to treatment. For example, in one area the red maples already dead had an average diameter of 5 inches, those with crowns reduced by more than 50 percent averaged 10 inches, while those with less than 50 percent reduction in crown had an average diameter of 14 inches.

Where complete frills were not used, the amount of crown reduction tended to vary inversely with the total width of life bars. Among the 6 inch red maples still surviving treatment on one area, total width of life bars was about 4 inches on the trees that showed no reduction in crown, about 2 inches on those with less than 50-percent reduction, and about 1.5 inches on those with more than 50-percent reduction.

Where proper techniques are used, even relatively low concentrations have sometimes given good results in the first year. For example, a custom applicator in North Jersey used only 12.5 pounds aehg. of a combination of 2,4,5-T and 2,4-D esters (1:2 ratio) in oil last winter, but he made overlapping cuts and probably applied 1.5 ml. or more per cut. By October nearly 80 percent of the treated stems were dead. In one 104-tree sample the kill included all ash, aspen, hornbeam, gray birch, black cherry, sassafras, and serviceberry; 90 percent of the oaks; 80 percent of the beech; 38 percent of the red maple; and 45 percent of the sweet birch.

UNDILUTED MATERIALS

The 1963 results from 1961 applications of undiluted materials on black oaks indicate again that technique, especially spacing of cuts, is highly important. Top kills after 2 years varied from 10 to 100 percent, as shown in the following tabulation:

<u>Treatment</u>	<u>Stems killed by treatment in</u>			
	<u>May</u>	<u>Aug</u>	<u>Oct</u>	<u>Jan</u>
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
Amine: 0.5 ml. per cut	80	100	90	100
1.0 ml. per cut	90	100	100	80
Ester: 0.5 ml. per cut	10	30	100	50
1.0 ml. per cut	90	90	100	50

Most of the trees that were still alive above breast height showed great crown reductions. All these trees had life bars. The fault in technique that permitted these trees to form life bars and survive was always in the spacing of effective cuts: at one or more places on a tree, the cuts would be 2 to 4 inches apart edge to edge; or if not literally that far apart, the effective portions of the cuts would be so spaced because the full width of the blade had not penetrated into the wood.

Undiluted materials of either formulation or amount evidently would be effective on this species if the cuts were made edge to edge or at spacings no greater than 1 inch. However, the amine would be somewhat quicker acting.

However, even at 0.5 ml. per cut, more chemical would be used than in diluted applications. On the basis of the usual commercial concentrate containing 4 pounds acid equivalent per gallon, 1.5 ml. per cut of 80-pound aehg. solution would contain 0.3 ml. of the concentrate; an equal volume of 40-pound aehg. solution would contain 0.15 ml. of the concentrate. Since these dilutions were as effective when properly applied as the larger dosages of active chemical in concentrated form, the use of diluted solutions seems advisable for the species and conditions found in our New Jersey and eastern Maryland timberlands.

RECOMMENDATIONS

In view of the results to date, these recommendations are made:

1. Make complete, fairly low frills wherever possible; be sure that cuts penetrate through the bark for the full width of the blade.
2. Use either the ester or amine of 2,4,5-T. (Although a combination of 2,4-D and 2,4,5 T esters also might work satisfactorily, we do not have enough experience with such mixtures to recommend them.) In choosing the material, remember that amines are quicker acting on the

oaks than the ester, but slower acting on red maple, dogwood, and holly.

3. For high kills the first year, use 80-pound aëhg. solutions. If high kills at the end of 2 years are acceptable, concentrations of 20 or 40 pounds aëhg. will suffice. Use about 1.5 ml. of solution per cut.

These recommendations specify somewhat lighter dosages than the 2.0 ml. per cut of 80-pound aëhg. solution that were recommended in our report last year. Additional experience with complete frills possibly may warrant even further reductions in amount of solution per cut or in concentration.

TREE INJECTION OF UNDILUTED AMINES AND ESTERS OF 2,4,5-T
IN SPACED AND CONNECTED HACKS IN MASSACHUSETTS¹

by

William P. MacConnell² and Richard G. Babeu³

An important phase of forest management is controlling the development of unwanted species and poor quality individuals to provide growing space for trees of better species and quality in existing forest stands. Foresters have struggled with this problem for centuries to develop efficient and economical techniques. Both mechanical and chemical techniques are used and much active research continues in an effort to improve methods of control in order to produce high quality, fast growing forests.

The most popular methods of controlling unwanted hardwoods are (1) the application of the ester form of 2,4,5-T in oil applied in ax frills at a convenient chopping height, and (2) the application of the same herbicide using tree injectors. This is an easier and more economical method of application which also reduces sprouting because herbicide application is made near ground level (Peevey 1960). More recently there has been interest in applying the herbicide full strength in small amounts by tree injectors and using the amine form of 2,4,5-T instead of its ester form (Carvell, 1959; Starr 1963). To compare the cost and effectiveness of these newer methods on northern species, amine and ester forms of 2,4,5-T full strength were matched in several tests and compared with the standard oil-can-and-ax treatment generally employed in this region.

Because the most difficult trees to kill in the Northeast are the maples, an area having a predominance of maple was selected for treatment and the data for this species group were kept separate. Two thousand forty-five trees from 4 inches to 25 inches d.b.h. were treated on twenty-one acres of land.

METHODS AND RESULTS

Nine one acre plots were treated by various methods during the first week in June 1961. Observations of results were made during the month of September in 1961, 1962, and 1963. One acre was done by the oil-can-and-ax system of application and the other eight acres were treated with the tree injector using spaced and connected hacks. Similar treatment on twelve more acres was

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carried out to more accurately establish the cost of treatment. Plots were laid out and the trees marked, measured and tallied in 1" d.b.h. classes in advance of treatment. Tree selection, a fixed cost of any method, was not included in the cost data. The same two men were used to do all the work in order to keep work rates constant.

The connected ax frills with the ester form of 2,4,5-T at 19 to 1 in kerosene applied with an Eagle Oiler has long been the most popular method of controlling hardwoods in New England. One acre of this treatment was made for observation of results and four additional acres were done to establish costs. The 2,4,5-T used in this and all later tests had four pounds acid equivalent per gallon. A total of 619 trees were treated by this method.

Control was fair to good on maple and excellent on all other species (Table 1). The kill, however, was slow and did not reach acceptable levels until two years after treatment. Maple trees over 12 inches did not show a high percent of mortality by this method nor by any other method used.

Table 1. -- Percentage¹ of Control Observed on Maple after Ax Frill and Oil Can Treatment with 2,4,5-T² at 19 to 1 in Oil in Connected Hacks Using 5.0 Milliliters of Herbicide per Hack

Year Observed	Tree Condition			
	Dead Trees ³	Severely Damaged ⁴	Lightly Damaged ⁵	Undamaged ⁶
Trees 4" to 12" dbh				
1961	--	--	--	100
1962	49	35	16	--
1963	75	11	14	--
Trees 13" to 25" dbh				
1961	--	--	4	96
1962	21	51	8	20
1963	42	35	4	19

¹In percent of diameter inches treated.

²The ester form of 2,4,5-T at 4 pounds acid equivalent per gallon.

³Dead or nearly dead - eighty percent or more of the foliage gone.

⁴Severely damaged - fifty to 79% of the foliage gone.

⁵Damaged - twenty to 49% of the foliage gone.

⁶Undamaged - less than 20% of the foliage gone.

Tree injectors have long been in use in this country especially in the South. Until recently the most common mixture used in injectors was a 5 to 10 percent solution of the 2,4,5-T ester in oil. This was applied at the rate of about five milliliters per injection with the hacks spaced two inches apart around the base of the tree. More recently applications of undiluted herbicides in small amounts (.33 and .75 milliliters per hack) have been made

(Starr, 1963). The major advantage of using undiluted herbicides in tree injectors is that it reduces refill time for crews in the field.

Spaced hacks or other spaced treatments have been notably unsuccessful in killing northern hardwoods, especially those of larger size (Ryker and Minckler, 1962). In order to make a wider cut for economical connected hacks, a light weight tree injector¹ with a bit three inches wide and a curved cutting edge was selected for use. Herbicide was metered into the hacks by the rhythm of the operator as he pressed the injector against the tree. Hacks were counted and material was carefully measured to establish the average rate of application per hack. A quicker rhythm metered one-half milliliter per hack, a slower rhythm gave one milliliter per hack.

The connected injector frill with the amine form of 2,4,5-T full strength was matched against the ester form of the same material both at the rate of approximately 0.5 milliliters of concentrate per hack. One acre of each treatment was done to observe the results of treatment and an additional eight acres to more firmly establish cost of treatment. One thousand eighty-eight trees were treated by this method.

The amine form of 2,4,5-T yielded a greater kill than the ester form in the matched test (Table 2) and was more effective than the oil-can-and-ax treatment. The kerosene and ester mixture applied by oil can to ax frills proved more effective than the injector application of the ester form of 2,4,5-T full strength in this test. The amine killed trees at a more rapid rate than the ester. This could be important in situations where a rapid kill is desirable. The amine in this test proved to be the most efficient method of treating maple trees and other hard to kill species (Table 6).

The 1" spaced injector frill with 0.5 milliliters of amine concentrate applied per hack was compared with the same amount of ester also in 1" spaced hacks. One acre of each treatment was used for observation of results and to establish the cost of treatment. One hundred and twenty-seven trees were treated by this method. Fair to good control of maple was established with this method when amine is used on trees 12 inches or less in diameter (Table 3). When the ester form of 2,4,5-T was used control was poor on maple. This method proved very effective on easy to kill species of all diameters (Table 6).

The 2" spaced injector frill with 0.5 milliliters of the amine concentrate was matched against the ester in the same kind of treatment. One hundred and twenty-six trees were treated by this method. Here again the amine proved superior but neither chemical was effective (Table 4) when applied this way in maple or other hard to kill species (Table 6). Easy to kill species were controlled by this method with both amine and ester concentrates.

¹Cran-jector manufactured by Cranco Company, Trenton, N. J.

Table 2. -- Percentage¹ of Control Observed on Maple after Tree Injector Treatment with Amine and Ester Forms of 2,4,5-T Full Strength² in Connected Hacks Using 0.5 Milliliters of Herbicide per Hack

Year Observed:	Material:	Dead	Tree Condition		
			Severely Damaged	Lightly Damaged	Undamaged
Trees 4" to 12" dbh					
1961	Amine	65	11	20	4
	Ester	16	2	8	74
1962	Amine	93	3	4	--
	Ester	46	10	14	30
1963	Amine	93	3	4	--
	Ester	47	12	14	27
Trees 13 - 20" dbh					
1961	Amine	--	--	32	68
	Ester	--	--	8	92
1962	Amine	12	9	56	23
	Ester	14	8	29	49
1963	Amine	48	--	42	10
	Ester	26	15	53	91

¹In percent of diameter inches treated.

²Four pounds acid equivalent per gallon.

Table 3. -- Percentage¹ of Control Observed after Tree Injector Treatment with Amine and Ester Forms of 2,4,5-T Applied Full Strength in Hacks with 1" Spacing between Hacks and 0.5 Milliliters of Herbicide per Hack

Year Observed:	Material:	Dead	Tree Condition		
			Severely Damaged	Lightly Damaged	Undamaged
Trees 4" to 12" dbh					
1961	Amine	29	25	26	20
	Ester	28	11	27	34
1962	Amine	55	28	9	8
	Ester	32	20	18	30
1963	Amine	79	8	9	4
	Ester	45	28	5	22
Trees 13" to 21"					
1961	Amine	--	--	29	71
	Ester	5	--	6	89
1962	Amine	13	--	37	50
	Ester	5	--	27	68
1963	Amine	33	--	25	42
	Ester	5	6	27	62

¹In percent of diameter inches treated.

Table 4. -- Percentage¹ of Control Observed after Tree Injector Treatment with Amine and Ester Forms of 2,4,5-T Full Strength in Hacks with 2" Spacing Between Hacks and 0.5 Milliliters of Herbicide per Hack

Year Observed:	Material	Dead	Tree Condition		
			Severely Damaged	Lightly Damaged	Undamaged
Trees 4" to 12" dbh					
1961	Amine	21	6	24	49
	Ester	3	--	2	95
1962	Amine	24	6	22	48
	Ester	10	--	19	71
1963	Amine	28	6	22	44
	Ester	12	--	22	66
Trees 13" to 22" dbh					
1961	Amine	--	12	--	88
	Ester	--	--	--	100
1962	Amine	--	24	--	76
	Ester	--	--	25	75
1963	Amine	--	24	--	76
	Ester	--	--	25	75

¹In percent of diameter inches treated.

Table 5. -- Percentage¹ of Control Observed after Tree Injector Treatment with Amine and Ester Forms of 2,4,5-T Full Strength in Hacks with 2" Spacing between Hacks and 1.0 Milliliters of Herbicide per Hack

Year Observed:	Material	Dead	Tree Condition		
			Severely Damaged	Lightly Damaged	Undamaged
Trees 4" to 12" dbh					
1961	Amine	17	23	23	37
	Ester	10	11	6	73
1962	Amine	27	18	33	22
	Ester	15	5	11	69
1963	Amine	48	11	19	22
	Ester	40	6	13	41
Trees 13" to 21" dbh					
1961	Amine	--	--	10	90
	Ester	--	--	--	100
1962	Amine	--	10	--	90
	Ester	--	--	32	68
1963	Amine	36	--	33	31
	Ester	13	--	19	73

¹In percent of diameter inches treated.

The 2" spaced injector frill with 1.0 milliliters of the amine concentrate was matched against the ester forms of 2,4,5-T in the same treatment. Eighty-five trees were treated by this method. The amine again proved superior but neither treatment caused sufficient kill on maple (Table 5). This treatment like all the others proved effective on easy to kill species (Table 6).

The effect of the various treatments on maple and other species are summarized in Table 6. Three hundred and sixty-three maple trees and 164 trees of other species were treated, measured, and analyzed after the first, second, and third growing season to determine the results of treatment in the various tests. Because of the smaller number of other species treated, the results for these other species are less reliable than for the maples. In general hard to kill species like elm, hickory and ironwood respond like the maples. Easy to kill species like oak, birch, pin cherry and ash responded well to all treatments. In this class ash is somewhat harder to kill than the others. Of the methods employed only the (1) oil-can-and-ax application of the oil and ester mixture, (2) injector treatment with undiluted amine in connected hacks, and (3) injector treatment of the amine concentrate in hacks spaced one inch apart produced acceptable levels of mortality on maple and hard to kill species like elm, hickory and ironwood (Table 6).

Table 6. -- Percentage¹ of Treated Trees Killed² by Species, Method, and Herbicide

Method	Herbicide	Species		
		Maple	Hard to kill ³	Easy to kill ⁴
		Species	Species	Species
Ax and oil can application 5.0 ml herbicide per hack	Ester+oil	60%	100%	100%
Injector connected hacks 0.5 ml concentrate per hack	Amine	82%	100%	100%
	Ester	50%	50%	100%
Injector 1" spaced hacks 0.5 ml concentrate per hack	Amine	70%	50%	100%
	Ester	36%	40%	93%
Injector 2" spaced hacks 0.5 ml concentrate per hack	Amine	24%	30%	100%
	Ester	15%	0%	85%
Injector 2" spaced hacks 1 ml concentrate per hack	Amine	44%	0%	94%
	Ester	33%	0%	67%

¹Percentage of the number of trees treated

²Eighty percent or more of the foliage gone two years after treatment

³Elm, hickory, ironwood

⁴Oak, birch, ash, pin cherry

Table 7. -- Labor and Materials Required to Treat 1,000 Diameter Inches
of Cull Trees by Various Methods (In Dollars).

Method	Cost per 1,000 diameter inches					Total Cost
	Man Hours	Labor Cost	Material Cost	Equipment Cost		
Ax & oil can application	4.16	6.24	.38	.08		6.70
Injector, connected hacks	3.26	4.89	1.67	.18		6.74
Injector, 1" spaced hacks	2.45	3.67	.95	.12		4.74
0.5 ml per hack						
Injector, 2" spaced hacks	2.51	3.76	.95	.12		4.83
0.5 ml per hack						
Injector, 2" spaced hacks	2.51	3.76	1.90	.12		5.78
1.0 ml per hack						

Based on:

Labor - \$1.50 per hour wages
 Injector - .05 per hour depreciation
 Ax & oil can - .02 per hour depreciation
 2,4,5-T concentrate - \$9.00 per gal. cost
 Kerosene - .20 per gal. cost

Table 8. Cost Comparison of Five Methods of Treating or Killing 1,000
Diameter Inches of Cull Maple Trees (In Dollars)

Method	Herbicide	Cost per 1,000 Diameter Inches		
		Treated	Killed	
Ax frill and oil can	Ester	\$ 6.70	\$ 8.91	\$15.95
Injector girdle	Amine	6.74	7.28	14.02
Connected hacks	Ester	6.74	14.36	25.95
Injector girdle	Amine	4.74	6.02	14.36
1" spaced hacks	Ester	4.74	10.52	94.80
Injector girdle	Amine	4.83	17.24	None
2" spaced hacks	Ester	4.83	40.23	Killed
Injector girdle	Amine	5.78	12.02	16.07
2" spaced hacks	Ester	5.78	14.45	44.45
1 ml per hack				

COST

Two thousand forty-five trees were treated and measured to determine cost of operations.

Labor cost is lower with the tree injector method because both the hack and herbicide is applied in a single operation. Material cost, on the other hand, is several times greater for the undiluted herbicide applied by injector than for the oil mixture applied by oil can and ax (Table 7). Total costs of treatment, including labor, material, and equipment depreciation, were comparable when made either by injector with connected hacks or complete frills by ax and oil can.

When cost is computed on the basis of diameter inches of cull maple trees killed (Table 8), the injector with amine concentrate proves more economical than the 19:1 mixture applied by oil can and ax. The injector method with 1" spaced hacks was least costly, the injector method with connected hacks followed, and use of the oil can and ax was third. Other treatments probably should not be considered for use in this region for killing maples and other hard to control species. The injector treatment with connected hacks with its 93% kill on maple trees 12" dbh or less (Table 2) is probably preferable over the 1" spaced hacks with 79% kill (Table 3) even though the cost per 1,000 inches of diameter killed is greater. Even in the larger diameter classes, 13 through 25, the relationship is still favorable, producing 48% kill with connected hacks as opposed to 33% with 1" spaces. The cost of killing large trees is double or nearly double the cost of killing small trees. Clearly, an efficient and economical method of killing large, hard-to-kill species needs to be developed.

CONCLUSIONS

The nine methods studied differed in effectiveness of control on maple and other hard to kill species. All methods produced high mortality on easy to kill species. The amine form of 2,4,5-T proved more effective than the ester in every test where they were compared. Since amine and ester forms of 2,4,5-T are the same price, the amine form is much to be preferred for use in tree injectors in concentrate form. The oil can and ax method of killing trees is reliable, but the tree injector method reduces cost 20 to 30 percent based on diameter inches of trees treated. The tree injector will pay for itself in a relatively short time by doing a better job at lower cost.

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CHEMICAL WEED CONTROL APPLIED PRE-EMERGENCE TO POTATOES¹

Arthur Hawkins²

The effectiveness of relatively new chemicals, surface-applied as spray formulations pre-emergence to potatoes for control of annual grasses, broad-leaf weeds and nutgrass in 1963, was determined on fine sandy loam and silt loam soils in the Connecticut River Valley. The need for double cultivation to incorporate EPTC for control of nutgrass and other weeds is also presented.

Materials and Methods

Commercial fields of Katahdin potatoes with a history of crabgrass and broadleaf weeds, or nutgrass infestation in the Connecticut River Valley were selected for test sites.

For nutgrass control EPTC was applied five days before emergence. The other chemicals were applied a day or two before emergence of the potatoes. Prior to treatment the fields had been cultivated and the rows simultaneously "dragged-off" by a weeder mounted behind a tractor.

Spray formulations of the chemicals were applied with a 3 gallon hand sprayer equipped with a T Jet nozzle, at 100 gallons solution per acre rate on plots 3 rows wide x 12 feet long. Yields were made on 2 rows x 8 feet. Plots were replicated 3 to 4 times in most instances.

The very fine sandy loam soil at location C-1 and silt loam at C-2 was moist at time of application of materials; 1/2" to 3/4" of rain had occurred on 6/6 and 6/11. It was very hot and dry week of June 23 until a 2" shower on 6/28; the following week was hot with 1/2 inch rain 7/3. The balance of the season was warm and dry. Irrigation was applied only at Farm H.

Results and Discussion

DCPA: At Farm C-1; the spray formulation of DCPA was applied on 6/7/63 after 3 pounds DNBP per acre had been sprayed on by the grower the previous day; the fine sandy loam soil was free of weeds. DCPA at 4 pounds active per acre was as good as 6 pounds in controlling a heavy infestation of crabgrass (Table 1). On 7/3/63 the control plot had grass 4 to 6 inches high; the treated plots were free of grass but some weak lambsquarter persisted. The treated plots were relatively grass-free at harvest time while the check plot had considerable grass.

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TABLE 1. Effect of Spray Formulation of DCPA¹/Applied on Soil Surface Pre-emergence to Potatoes on Crabgrass Control and Yield of Katahdin Potatoes -- Connecticut - 1963. Season: Hot and Dry, No Irrigation.

Chemical	Active lbs/A	Crabgrass Control ^{2/}		Crop Rating ³	Yield ^{6/} bu/A
		7/3	9/24		
Farm C-1 - No weed growth at time of application. DNEP previous day ^{4/}					
DCPA 75WP	0	1	3	10	510
applied	4	10	9	10	520
6/7	6	10	9	10	538
Farm C-2 - Grass and broadleaf weeds 1/2", DNEP applied following day ^{5/}					
DCPA 75 WP	0	2	2	10	337
applied	4	5	4	10	367
6/12	6	7	5	10	362
	8	9	7	10	412

¹/DCPA = dacthal

²/Weed rating: 10 = complete control; 7 = acceptable; 3 = poor control; 1 = heavy rank weed growth.

³/Crop rating: 10 = no effect; 0 = complete kill.

⁴/Rows "dragged off" sometime previously. DNEP at 3 lbs./acre applied day before DCPA. Yield on Farm C-1: on single rows x 8 ft. x 2 reps.

⁵/Rows "dragged off" sometime previously. DNEP at 3 lbs./acre applied day after DCPA. Yield on Farm C-2: 2 rows x 8 ft. x 3 reps.

⁶/Season dry, no irrigation.

At Farm C-2, broadleaf weeds and grasses were up to 1/2" at time of application of 4 to 8 pounds DCPA on 6/12/63. DNEP was applied at 3 pounds per acre over-all by the grower on the following day. At the time that potatoes were ready to hill, 7/3/63, the check plots had considerable crabgrass; plots treated with the 6 pound rate had fair control, and plots with the 8 pound rate had good control of grass, Table 1.

At both locations no injury to potatoes was noted. Cultivation was omitted from time of drag-off until 7/3/63. Control of crabgrass at location C-2 resulted in slightly higher yields. No control was obtained at another location where grasses were 1/2" to 1" high at the time of application of 4 and 6 pounds active DCPA per acre.

Dyphenamid and Trifluralin: The field had been cultivated and dragged off about a week prior to application of treatments; broadleaf weeds and grasses were 1/2" high. The treatments were applied in four blocks; alternate blocks were raked free of weeds prior to treatments to determine the effect of treatments on emerged weeds.

Better weed control was obtained where dyphenamid and trifluralin were applied after the small weeds were raked out. Trifluralin at 2 pounds and dyphenamid at 4 to 6 pounds active per acre applied pre-emergence to potatoes gave good control of weeds until time to hill potatoes, when applied either pre-emergence to the weeds or if the grassy and broadleaf weeds were 1/2" high.

Trifluralin at 2 pounds gave as good control as dyphenamid at 6 pounds. The higher rates of trifluralin gave better season control of weeds, Table 2.

TABLE 2. Effect of Dyphenamid and Trifluralin Surface Applied Pre-emergence to Potatoes on Weed Control and Yield of Katahdin Potatoes -- Connecticut 1963 - Hot Dry July & August - No Irrigation - Farm C-2^{1/}

Chemical Applied 6/12	Active lbs/A	Control of Weeds ^{2/}		Yields ^{5/} bu/A
		6/25	9/24	
<u>Weeds raked out before treatment^{3/}</u>				
Dyphenamid wp	4	8	4	288
	6	9	7	278
Trifluralin ec	2	9	7	277
	4	10	8	325
	6	10	8	320
Check		2	2	245 ^{6/}
<u>Weeds 1/4 - 1/2" at time of treatment^{4/}</u>				
Dyphenamid wp	4	4	4	211
	6	8	8	237
Trifluralin ec	2	8	4	237
	4	9	6	315
	6	10	8	324
Check		2	1 1/2	182 ^{6/}

^{1/}Dragged off about one week prior to treatments.

^{2/}Weeds - primarily crabgrass and pigweed, also lambsquarter and barnyard grass.
Rating: 10 = complete control; 7 = acceptable; 3 = poor control;
1 = heavy rank weed growth.

^{3/}Weeds raked loose prior to treatment.

^{4/}Broadleaf weeds (lambsquarter and pigweed) and grass weeds (crabgrass, barnyard) were 1/4" - 1/2" high at time of treatment.

^{5/}Yield on 2 rows x 8 ft. x 2 reps.

^{6/}No cultivation, from time of drag-off 6/5 until all cultivated and hilled 7/3, favored weeds and resulted in greater than normal competition on check plots.

The plots were not cultivated from time of drag-off, 6/5, until hilled on 7/3 when potatoes were about 8 inches in height. Under the hot dry conditions on this unirrigated site, crabgrass and other weeds were favored since vine growth was not vigorous enough to shade weeds. It is assumed that the check plots, especially those in the blocks where weeds were not raked out just prior to time of treatment, had a higher weed population and produced lower yields than if normal cultivation practices had been employed.

Need For Good Soil Incorporation of EPTC

EPTC ec at 6 pounds active per acre was applied for control of nutgrass and other weeds two weeks after planting and about a week before emergence of potatoes for control of nutgrass and other weeds on Farm H. The material was applied in 13 gallons of solution per acre at 25 to 30 pounds pressure and was soil incorporated simultaneously while cultivating (1).

The equipment consisted of a low pressure power take-off pump, a mounted container for the spray solution, and spray nozzles mounted on a six-foot boom under the front part of the tractor (2). The nozzles were directed to spray the soil in front of the cultivator teeth.

The soil had been loosened the previous day; it was dry on the surface and mellow-moist underneath at the time of application. The material was incorporated by means of the cultivator teeth, and a six-foot weeder attached to the rear of the tractor.

To insure good soil incorporation of the EPTC, the treated rows were again cultivated and dragged-off by another tractor equipped with cultivators and weeder but without the spray equipment. The second cultivation was made within a few minutes after the first and was performed in the reverse direction.

The importance of adequate soil incorporation of the material was noted. Excellent control of nutgrass and other annual weeds was obtained where good soil incorporation was provided by cultivating and weeding twice. Control of nutgrass and other weeds was relatively poor on rows which received only one cultivation and weeding simultaneously with the application of the spray treatment.

MC31675 on Nutgrass Control

Monsanto Chemical 31675, 65 wp, was surface applied at 1 to 4 pounds active per acre following drag-off, about two days pre-emergence to potatoes at a location where nutgrass was heavily infested on fine sandy loam soil. Within two weeks it was noted that the treatments gave little control of nutgrass. The spring growth of nutgrass was then controlled by cultivation and hand weeding.

The residual effect of MC31675 on nutgrass which developed later was outstanding. By mid-September the check plot had a thick stand of nutgrass from row to row. Plots which had been treated with 1 or 2 pounds per acre had no nutgrass in the potato rows and only a small amount of nutgrass between the rows. Plots treated with 3 and 4 pounds in addition to being free of nutgrass in the rows, had only weak nutgrass plants between the rows. No injury to potatoes was noted. Treated plots produced as good or better yields than the check plot.

Adjoining areas which had been treated with 6 pounds EPTC at drag-off, soil incorporated by double cultivation, were relatively nutgrass-free early in the season, but had small but vigorous nutgrass plants growing between the potato rows by mid-September.

The results suggest that MC31675 WP be soil incorporated and applied earlier in the season in order to be effective against early germinating nutgrass.

Summary and Conclusions

New weed control chemicals applied pre-emergence to potatoes were evaluated in fields of Katahdin potatoes on fine sandy to silt loam soils on commercial farms in the Connecticut River Valley.

DCPA at 4 pounds per acre surface applied pre-emergence to potatoes and before weeds emerged gave excellent control of grasses until potatoes were ready to hill. Where grasses were 1/2" or less at time of application, 8 pounds gave good control.

Trifluralin at 2 pounds and dyphenamid at 4 to 6 pounds active per acre applied pre-emergence to potatoes gave good control of weeds until time to hill potatoes, when applied either pre-emergence to the weeds or if the grassy and broadleaf weeds were 1/2" high. Higher rates of trifluralin gave better season control of weeds.

MC31675 65 wp at rates as low as 1 pound active per acre applied on the surface pre-emergence to potatoes after drag-off gave good control of nutgrass which developed later in the season. It did not control early germinating nutgrass. Soil incorporation and earlier application is suggested for control of early nutgrass.

Double cultivation was found necessary to adequately soil incorporate EPTC ec spray applied at drag-off for control of nutgrass and other weeds. The method of simultaneously spray-applying EPTC and soil-incorporation while cultivating and weeding is discussed.

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