The Mechanics of Herbicide Application

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Herbicide applications have become a general practice in many fields of agricultural, industrial, and home enterprises since approximately 1945 when the "hormone" and "sulfanate" materials began to show.

Industry continues to work towards development of specifics in some cases, comprehensives in other cases. Yes, even growth "limiters" show new possibilities.

The purpose of this topic is to bring up to date the results of application mechanics that time has developed in order that future trends in equipment and techniques may be confirmed or established.

Requirements:

Present agricultural herbicide types are trending toward 20 to 40 gpa. Two or three important wettable powder items are nonsoluable in water thus requiring agitation before and during application.

I. Pumps

The total requirement of higher gallons per acre and agitation is larger or at least adequate size pump to permit efficient length booms, ground speed, and sufficient agitation.

a. Capacity for normal weed and forage insect spraying.

4 mph, 20 gpa, 12 nozzle boom satisfying required agitation calls for an 8-10 gpm pump. Agitation alone requires 2 to 8 gpm for certainty depending on type and size of drum and wettable powder load when jet or hydraulic agitation is used.

b. Types

1. Nylon Roller pumps continue to perform satisfactorily with all types of herbicides, including Atrazine in some reports, while in others, reports are not so good. Operators and farm advisors in the east report "that the durability of nylon roller pumps has been satisfactory;" and "we have been running into pump failures, especially in gear types and nylon rollers."

Thus it would appear that nylon roller pumps have a major place, considering good care, but need roller or entire pump replacement in some instances. Nylon Roller pumps are available in the price range of $50 - 100 depending on size.

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2. Piston and diaphram pumps are readily available at near $100 and are generally considered most practical where wettable powder type materials are to be used extensively.

3. Some Pump Types Include:

8 roller - 50 psi, approximately 540 rpm pto delivers 8-10 gpm wt. 12-14 lbs.

6 roller - 50 psi, approximately 540 rpm pto delivers 6-8 gpm wt. 10-12 lbs. Some 6 roller pumps with larger rollers and generally larger frame will deliver 20-25 gpm at 500 rpm, 50 psi, wt. 22 lbs.

4 piston - 50-500 psi, approximately 500 rpm pto delivers 6-12 gpm, wt. 15-60 lbs.

2 diaphram - 50-400 psi, "belt drive" delivers 10 gpm.

II. Some modern equipment features include:

Three-point hitch, up to 200 gallon tanks
Fiberglass tanks
Piston Pumps, 2 gpm to 50 gpm
Dripless nozzles
Agitators--hydraulic, electric, mechanical
Golf course wheel assembly--dual track, oversized tires
Versitile for insecticide use if equipped--sufficient pressure
sufficient gpm
hand gun fittings in line
May combine two smaller pumps for more capacity or agitation
Boomless sprayer heads
Rubber versus nylon rollers. Repair kits $7-8 for 8 roller pump; manufacturers suggest rubber for water only or for wettable powder slurries.

Also, several other features and rig accessories too numerous to mention are available.

Without putting all makes and models through comparable paces, its impossible for one to pick out the "Cadillac."

III. Observations of Herbicide Application Equipment Performances:

The glaring violations or shortcomings of equipment performances as reported by many farm advisors include:

a. Nozzle tip wear goes unnoticed too often and too long. With it, the inevitable overdose, crop injury, spray pattern change, and in some cases, soil residues. Manufacturers charts for nozzle set-up,

steel or other long lasting tips, frequent replacement or checking (recalibration), and frequent operator speed and pressure checks should correct this threat.

b. Plugged nozzles still common with many modern materials--not due to materials, but to improper mixing at time of use (nozzle and line screens too small--50 mesh or none, useful) and tank contamination under farm conditions--rust, hayseed, etc. Proper screen, if needed, rust proof tank, absolute prevention of tank contamination, and slurry of wettable powders before putting in the tank should correct this threat.

c. Pump Capacity not sufficient to supply line and agitator unless electric or mechanical agitation is provided. Hydraulic agitator requires from 2 to 8 gpm alone at 50 psi. Amount of agitation required is determined by load of nonwater soluable or emulsifiable materials in the tank and shape of the tank. Poor agitation still frequent. Jet agitators have been reported to wear holes in side of tank if placed close to sides.

d. Pressure gauges and mph indicators or judgment too often not accurate. Pressure gauges plug, rust or just plain jar out of condition. Zero to 100 gauge more useful than 0-400. Up and down hill mph variation not sufficiently recognized by operator, resulting in dosage variations unless alive pto or meter flow pump being used.

e. Boom height significance not understood by many farmer operators--too high or too low in relation to nozzle tip pattern and/or crop-weed height contributes to skip and overlaps (overdose).

f. Overlap, "skippers," spraydrift, and nozzle drip all contribute to poor control or crop injury and soil residues with some materials. "No drip" nozzles are available but only the operator can correct overlaps, drift, and skips. Dye indicators for boom end nozzle are available. (Dye material used in some commercial spraying in 1964 was Methylene Blue 2B from National Alkaline Division of Allied Chemical, 40 Rector Street New York 6, New York.) Urge treatment for weeds when wind is down.

g. Slow calibrated spray discharge at beginning of swath generally shows poor control and "messy" job. Independent power unit for sprayer "reving" up sprayer before entering field each bout; or live pto all help correct this threat.

h. Acre size. Farmer or rig operator "one acre" too frequently turns out to be 3/4 acre or 1 1/2 acre actually. Thus, he stretches or overdoses the load in compromise speed, or leaves part undone. A constant reminder of acre size (208' x 208') with a suggestion that "a pace" be checked would be useful.

IV. Some suggestions for improving herbicide usage for farmer and operator

guidance.

a. Atrazine is one of the most useful of these tools in the northeast. Yet, grower satisfaction and economic value varies greatly from year to year depending on soil moisture or more specifically rain occurrences. Too much Atrazine is applied in "dry periods" because farmers wait too long. I believe that extension service and other farm advisors could greatly improve farmer satisfaction here by developing an emergency or otherwise alerting advisory system for timing application and/or cultivating. TV, radio, mailer, and farm visit campaign at right time would be very helpful.

b. Similarly EPTC is too often wasted because soil surface at application is too moist.

c. Continued and expanded use of local demonstrations of herbicides appropriate to the area should be continued. Timely and appropriate interpretation of these to farm advisors and directly to farmers is a great program.

e. Clue the hired man rig operator into the principles of accuracy of dosage as affected by nozzle condition, boom arrangement, speed (up and down hill), drift, and response.

f. Nutsedge (nutgrass) control with Atrazine appears aided by cultivation. Satisfaction here is greatly reduced because "in row" grass plants are not disturbed by cultivation after the corn is up. Treatment on fallow or even higher doses at or post emergence may be needed here.

g. What should a farmer expect from each particular herbicide in relative areas? Help here would serve greatly to build confidence in herbicides and advisors. I believe farmers should know the rate and type of response from herbicides of his interest; what the limitations are in the way of weeds not generally satisfactorily controlled, kill versus suppression, and limits of dosage safety. For instance, 4-(2, 4-DB) results in fields of new seeding legumes often disappoints the farmer because he expects complete kill of most weeds. This, of course, does not occur with many species in any particular section. Yet, when it is explained that kill of some, suppression of others, and tolerence of others is expected and the relative amount of crop liberation pointed out, he is satisfied.

Diphenamid DCPA, EPTC, and many others have accepted limitations which when understood are allowed for in satisfaction standards. Research and demonstration plot records are full of sound observations and conclusions state by state of herbicide and weed species reaction. Yet, most farmers and farm advisors stumble all over the lot, condemning the material or practice or making excuses for poor performance. Should we not educate farmers more extensively to standards of expectation from herbicides according to state or local tests and demonstrations in relation to weed and grass species

tolerence versus succeptability?

V. The overall herbicide application program should include:

1. Farmer advisors, and where practical, hired man appreciation of overdose dangers, weed tolerence or what is expected of the material, plant and soil (weather) conditions that influence results of each material within reason.

2. Closed tanks or fool proof screening (50 mesh or none)

3. Built-in agitation, or provided for with every farm rig at installation time--something better than mere overflow.

4. Long wear nozzles.

5. Boom nozzle and height charts positive with every rig in a form that can be easily read by operator or posted for handy reference.

6. Sufficient size pump for gpa, mph, rpm, pressure and agitation desired.

7. Right material at right time, in right amounts applied correctly.

This combination of requirements involves effort by equipment dealers, extension service, and other farm advisors. This is our obligation.

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OTHER DIMENSIONS OF THE WEED PROBLEM

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At a conference in this city a few years ago, one of the speakers was reflecting upon the stations we have passed in our research on agricultural chemicals. He remembered the time, a few decades ago, when Boysen-Jensen in Denmark and Went in Holland were exploring the possibility that special growth regulating chemicals might be at work in plants. He wondered what the result might have been for biology if a farmers' group in each of these countries had visited the scientists to say, "Our weed problems in agriculture are very severe, can you turn your efforts toward the discovery of a new magic chemical that will assist us in our fields?" The scientists were not so interrupted, but out of their tenacious pursuit of information about the chemistry of plants came, among other things, the possibility that one species of green, higher plant could be removed while growing in the presence of others. And because of these discoveries we have come together for a meeting such as this one.

In 1929, the British bacteriologist, Alexander Fleming, was going about his business in his laboratory when he noticed that a plate containing staphylococci had become contaminated by a mold. He noticed that the staphylococci had <u>not grown</u> in the neighborhood of this mold. Perhaps you will recall that 10 years later, Chain and Florey had isolated and purified the substance to which they gave the name "penicillin". This antibiotic, and those which followed, opened a new era in medicine and brought about significant changes in our philosophy and our understanding of infectious diseases. I remind you that Sir Alexander Fleming was not looking for an antibiotic.

Today we are heavily committed, in our research, to the use of synthetic chemicals in the hope that appropriate combinations will help us in the control of weeds. We have made some strides, but I suspect that those present know now where the hard places are. Some of you have also recognized that the easy work has been done and that we are not making absolute gains in reducing the numbers of weeds in our fields. In far too many areas our weeds have shown a remarkable plasticity in their adaptation to annual applications of herbicides. We have reached a sort of steady state and can look forward only to continued applications of herbicides. We are aware also that this procedure is highly suspect among some groups in our society.

Is it possible that significant help may still come from another source? If we should turn a greater share of our effort to the search for an understanding of the biology of our species, and of the systems we are dealing with, there may be revealed to us new and larger insights which will serve us in those hard places. Our lessons may be in the changes wrought in the biological world by the discoveries of Boysen-Jensen, Went, and Fleming. These men were not looking for herbicides and antibiotics.

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If there had been houses on the moon, we are told that Ranger 7 would have relayed back to earth distinct photographs of them just before the impact. It has also been suggested that the windows of such a house would have been visible and possibly the dim outline of objects in a room beyond the window. But we cannot expect to find such clarity and precision as we attempt to take the measure of the problem which confronts us here. Are there better herbicides for higher plants already at work in the natural environment? In the microbiological world such chemicals were found. Are there sophisticated systems of biological control which have not come to our attention? Ought we to turn our attention to the destruction of the seeds of weeds rather than the seedlings and adults of the species?

In the remaining time I should like to tell you some stories that will touch down upon many places in the biological world. Some are concerned with work accomplished--others may only leave us puzzled. There is no significance in the order in which they will be presented. That I may be understood, I wish you to know that I intend them as an anthology rather than a comprehensive review of an area so large that it could not be presented in the brief period we have together.

I shall begin as most plants begin--with the seed. Forty years ago, W.J.C. Kooper, a Dutch ecologist working in Java, reported a discovery about weeds which is little known but which may be full of meaning for our future. He was studying a large plain where the crops were sugar, rice and corn. After harvesting, the fields were plowed immediately and sometimes left fallow for months. During this period a very dense cover of weeds developed, and several very distinct weed communities could be recognized. The floristic composition of each community was rather stable, as were the proportionate numbers of each species. In a given spot, he always found the same weed community each year. Perhaps his most important finding was that the floristic composition of each community was already determined at the earliest stages of germination. This tells us that the composition of a weed community is not determined by the survival rate, or by a struggle for existence, but by differential germination. He gave direct proof of this by showing that the seeds of other species were present but could not germinate. When he planted foreign species in the community, they did not appear. He concluded that the residues from previous vegetation and the seeds already present in the soil had a very important role in determining the particular weed species which could germinate and become established in a given weed community. This is a strange tale for our ears.

One of my students, Mr. Gressel, has spent some time on this problem. He studied the seeds of some of the species in 10 plant families and found, indeed, that seeds may give off chemical substances which have intense biological activity. His work then was a search for seeds with biological activity and a study of the chemical and physical properties of the substances which have this potential. In this brief period I can scarcely do more than enumerate some of his findings. He found that the seed of a particular species could not only inhibit the germination of the seeds of several crops and weed species, but the inhibition was species specific. Some were only mildly affected while for others the inhibition was complete. Perhaps one of the explanations for the species specificity is even more interesting. The toxicity was seldom expressed as only the failure to

germinate, or a very much delayed germination. In some species the root tips were killed, in some the radicle appeared but failed to grow, and in others there were abnormal shapes and swellings as the new organs appeared. These effects could be elicited by intact seeds or extracts of seeds.

Abutilon theophrasti was the weed chosen for the most intensive study. Tomato seedlings were used for a bioassay. The inhibiting substance (S) was shown to come from the embryo-endosperm complex. It is insensitive to light, is not volatile, is stable to 110° C, and is organic. Extraction with a series of polar to non-polar solvents removed only a small amount of the activity. After much work with ion exchange partition and chromatography it was learned that the active fraction was amphoteric. It was not released from free acid or free base forms of the resins. Amino acids constitute one of the principal groups of organic compounds which are water soluble, ether insoluble, heat stable, and amphoteric. It is possible to precipitate amino acids selectively from a solution (Neuberg precipitation). A precipitate of the seed extract obtained in this way was ninhydrin-positive and in a dilution series had almost identical activity with the crude Abutilon seed extract. We presume this is a mixture of amino acids but at present we do not know their identity.

Is it possible that such strange inhibitory and formative effects can be due to the biological activity of amino acids? Of course it is possible! The work of Woltz has shown that the leaves of chrysanthemum lose their chlorophyll and become deformed when norleucine, methionine, and ethionine are mixed with the soil.

I would like for us not to get lost here but we must not miss the opportunity to appreciate in this context the significant biological activity of other natural amino acids. Fowden in England has been studying a homologous series of amino acids found in plants. As you may see from the blackboard, proline has a five-membered ring with a carboxyl group, and with a nitrogen in the ring. Azetidine-2-carboxylic acid is the same in all respects except that it has a four-membered ring. So also with pipecolic acid except that it has a six-membered ring. All are natural amino acids found in plants but only proline is a constituent of protein. Now when azetidine carboxylic acid was given to imbibing seeds of mung bean, peanut, and cucumber, the radicle growth of the young seedlings was almost completely inhibited. He has shown further that this amino acid was substituted for proline, a normal constituent of the radicle protein. He points out that incorporation of azetidine carboxylic acid residues may turn the helix of the protein through an angle about 15° smaller than proline. This alteration of structure may be the cause of the difficulty in the radicles of the young seedlings. To bring our speculation down to earth, the third amino acid, pipecolic, is very closely related to the new herbicide which we know as "Tordon".

In a recent communication from Prof. Grodzinsky at the Botanical Institute in Kiev, there is information about a similar finding with the seed of Crambe tataria, a member of the Cruciferea. The substance he is working with is also ninhydrin-positive, is amphoteric, and strongly inhibits the growth of wheat coleoptiles. The unusual substance which is present only during the rest period, is not adsorbed by the soil particles and has had no effect on

several species of microorganisms which he has studied. These characteristics could indeed suggest an interesting ecological role.

Many of you believe, I know, that we are severely handicapped in our weed control operations because we cannot penetrate the barrier of seed dormancy. Failure to do this leaves us with a dreadful weed potential for most fields. We felt that one of the needs for further exploration of seed dormancy was a method of "producing" dormany and non-dormant seed of a species in a controlled environment.

One of my students, Mr. Wentland, has shown that C. album, when grown at 70° F, will produce seed which is about 85% dormant in a 17-hour photoperiod, and only about 15% dormant when grown in an 8-hour photoperiod. He has shown that the dormant condition is a function of the photoperiod and is not dependent on the total light energy received. The photoperiod seems to be influential in controlling dormancy from very early stages of growth. For example, plants which began life in an 8-hour day (a photoperiod which normally results in a very low percentage of dormant seeds), and which were transferred to a 17-hour photoperiod just as the first flowers appeared, produced seeds which were 60 per cent dormant when the plant had grown to maturity. In this case the plant had spent the last 96 days of its life in a 17-hour photoperiod.

When, however, the plants grown in the same 8-hour photoperiod were transferred to the long photoperiod just as flowering was completed (and most seeds were present but immature), only 17 per cent of the seed was dormant. In this case the plant lived in a 17-hour photoperiod for only the final 54 days of its life. From some preliminary work on the chemistry of these seeds we know that there are inhibitors present in the embryo-endosperm complex. Acetone extracts were made of dormant and non-dormant seeds (from 17- and 8-hour photoperiods respectively) and these were chromatographed in an isopropanol-ammonia-water system. The active fractions from the chromotograms were used in a bioassay of root growth of C. album and Lepidium sativum. Thus far, in all instances, the dormant seeds have given significantly greater inhibition than the dormant seeds.

There are some other aspects of the influence of higher plants on one another which are interesting. You have all seen evidence in the laboratory, or in photographs, of the production of antibiotics by a fungus culture growing on an agar plate which has been inoculated with another fungus or bacterium. A clear zone of inhibition, such as Fleming found, is seen in which the chemical has diffused out to prevent the growth of other organisms. This is truly a view of one organism as it inhibits the growth of other similar organisms through the production of an antibiotic--a substance whose structure we can define. Antibiotics are the herbicides of microorganisms.

I have seen a similar phenomenon on the polders in The Netherlands. Dr. Bakker, an ecologist, showed me "holes", or zones of inhibition, caused by one green plant when growing in the presence of others. Catabrosa aquatica, brookgrass, and Tussilago farfara, coltsfoot, are able to exert this influence in areas where the surrounding lush vegetation, Phragmites and

Senecio, is 1 to 2 meters tall. The effect may be exerted for many months after the plants are gone. By comparison, this represents the inhibition of growth of one organism by another through the production of an unknown substance, or through some means which we do not understand.

I must mention here a very interesting and imaginative piece of research which has just been reported by Muller and his co-workers at the University of California at Santa Barbara. Their attention was drawn to the curious patterning and spacing of annual grassland species in the vicinity of Salvia and Artemesia shrub species in one of the valleys near Santa Barbara. Annual grasses and forbs were absent from shrub patches and the soil was bare for a distance of 60 to 90 cm beyond the canopy. There was evidence of further differential inhibition to a distance of 9 meters. After much study it was suspected that volatile inhibitors from the leaves of the shrub were trapped in the dew at night and then deposited on the nearby soil and vegetation. Artificial dew was produced from the atmosphere in several places where plants of Salvia leucophylla were growing, as well as in areas which were free from these plants. The dew was condensed on cooling coils and the condensate inhibited the growth of the roots of Cucumis and of the seedlings of Avena. This may be the first demonstration that a volatile inhibitor can be effective in the field, and in the author's words, "It would constitute a novel mechanism of ecological interaction."

In an effort to find a more suitable system in which to study the effect of one plant upon another, we have been trying to find a sterile medium on which weed seedlings and root tips will grow. At this time we think we may be able to culture the seedlings of Polygonum pennsylvanicum on floating pads of plastic foam. In our first trial, the excised root tips of tomato were completely inhibited when placed in the flasks with the weed seedlings. This is a preliminary result and we did not have the time to repeat it before I came here. If we can do this successfully, it will mean that we may study the inhibitory substance in a medium in which every component is known except that which is excreted from the roots of Polygonum.

The effect of a plant species may linger in the soil from one season to the next. Winter and Schonbeck in Germany made extracts of essential oils from the residues of plant leaves, stems, and roots which were returned to the soil. When these volatile extracts were placed in the lower portion of a Petri dish, and when representatives from the major groups of soil microorganisms were streaked on agar on the underside of the covers of the dishes, they found that the growth of many of the organisms was inhibited. We may ask what effect such residues may have on delicate root tips and on the tiny seedlings which emerge from small seeds in the soil. They and others have shown that the substances extracted from grain stubble left in the field may very well affect the germination of some seeds and the growth of seedlings. The effect is so specific that the soil under the stubble yields more of the potent substance than the soil between the rows.

Patrick and his wo-workers in Canada have studied the problem of residues of specific crops on the growth and development of tobacco. There are many similar studies about the world on this and other crops. I have chosen this excellent work because it demonstrates a very strange phenomenon. Tobacco

seeds germinate well and grow to good size in Petri dishes in the first six days. If an extract is made of a soil in which timothy residues have been allowed to decay for 21 days, and if this extract is added to the dish of tobacco seedlings, the root tips become blackened in 1 hour. The region of elongation remains healthy. If, however, the extract is made from rye residues, the root tips remain healthy and the region of elongation becomes black and is seriously injured. This remarkable demonstration of the extreme specificity of these toxins ought to be a reminder to us of the work we have yet to do in our weed-crop relations.

These are some of the other dimensions of the weed problem in agriculture. They represent a vast and unexplored wonderland in which we shall find much that is exciting, and from which we may learn some things about higher plants that we could not know in any other way. Some of you are already working in this area. I believe that noone would take the extreme view that every plant is a positive aggressor wherever it grows and that it is rich in new toxic substances. We know that Nature is never this consistent about anything that she does. Only a small measure of the same kind of logic is needed, however, to see that Mother Nature may not be expected to provide the other extreme--a world of plants which are all innocuous. Between these we will gind her pattern and we will know it only when we have consented to labor over her individual species.

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STANDARDIZATION OF TERMINOLOGY IN WEED SCIENCE

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Advancements in weed science depend in part on our ability to communicate. As science becomes specialized, accuracy of expression and simplified standard terms are needed. The problem of improved terminology is common to all scientific fields, particularly those concerned with use of chemicals on plants and animals. It is important to develop and adopt common names for herbicides and weeds for use in publications and oral reports.

We have a very specific system of binomial nomenclature for plants. However, both laymen and scientists often find common names the more convenient. Because common names for the same weed species vary from locality to locality there is a need to standardize common names for regional and national publications. Their wide use by scientists, extension personnel and company representatives, will bring about the desired change even on the popular level.

A system of chemical nomenclature, used by Chemical Abstracts, adequately describes herbicidal chemicals. Many of these names are complex. Rapid communication requires designations simpler than the chemical names in writing and orally. In the belief that common names for plants and for herbicides and other matters of terminology should be acceptable nationally, the Weed Society of America appointed a Terminology Committee. Its aim is twofold: (1) to coordinate terminology in weed science, including selection and approval of common names for herbicides and weeds; and (2) to review, revise, and develop standardized terms, abbreviations and definitions used in weed science.

Members of this Committee and its Subcommittees are your own colleagues in industry, or in university and government positions. They conscientiously consider policies, needs and procedures in order to serve weed science. They attempt to deal in principles beneficial to the science of weed control. The Committee, in dealing with matters of terminology, does not claim infallible judgment. They admit to past mistakes and I, for one, assume that we will make others in the future. They welcome suggestions.

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Development of common names for herbicides is one of the more difficult problems. Why should we have common names? Why not use letter-number designations only or why not use trademark names only? Why do we have a few common names that differ from those used in foreign countries? These are questions that are asked almost every day. Therefore, I shall now deal with them, one by one.

Why should we have common names? In the first place, many foreign countries will accept only names for new herbicides. They will not accept letter-number combinations. With the present free exchange of publications, and other international information, it is necessary for our terminology to be acceptable internationally. Therefore, for herbicides, we feel there is reason to give favorable consideration to the use of common names rather than other designations because they are easier to pronounce and remember than letters and numbers. For instance, dicamba is but one word, three syllables, compared to the number-letter combination, 2,3,6-TBA, for which six distinct words are spoken — as much as a short sentence. Also, typographical errors are more easily avoided. When names are misspelled, they often result in unpronounceable words.

Why not use the trademark name? Their purpose is to help sell the product. These usually apply to a formulated product not officially connected with any single chemical. Chemical names do not ordinarily appear in the "official trademark file," which usually contains some general classification such as "a weed killing chemical."

Companies can, and do, use a trademark name to sell completely different chemicals at various times. This is justified in that trademarks are the property of the company. This can lead to confusion when a trademark name is published in extension circulars, research reports, or other published material, as though it represents a specific chemical. These same publications would be giving misinformation if later a different herbicide were sold under that trademark name. Particularly vulnerable are those using only trademark names without adding the chemical name.

We have no right to ask a company to limit the use of their own registered trademark name. They have an investment to protect. Yet we do have a responsibility, as scientists, of developing a clear, exact system of communication.

Recently I saw a letter from a colleague who had attended a meeting on weed control research outside the United States. Foreign trademark names, even in English speaking countries, often differ from those in the United States. Some research reports used only trademark names. My colleague, after considerable conversation with the investigator, was able to identify some of the herbicides mentioned but to this day, he doesn't know what others were. Or take another example to illustrate

the need for standardization. Not long ago, the U. S. Department of Agriculture received a letter from a South American. It said that since a certain herbicide had been used, the farmer was not able to grow crops on his land. Obviously, since the brand name was completely foreign to us, we were unable to make suggestions to him. If he had used a standardized common name, or the chemical name for the herbicide, we might have been of some assistance to him.

Many individual herbicides are being sold under more than one trade name. Multiple listing of all the trade names for a given herbicide is difficult in either publications or in speaking. If we mention some trade names without listing them all, we are being unfair to some companies. For instance, how many of you could give all the trade names for disodium methanearsonate (DSMA)? I know I can't. To be fair to all companies selling DSMA, we would have to use the full chemical name or a common designation. You do not need to be reminded of the complex chemical names of herbicides to realize fully that chemical names are not suitable for common use. We must, if you please, have simpler common names for the pure chemical that is the active herbicidal ingredient.

These are some of the reasons the WSA Terminology Committee has been instructed to promote the adoption of common names for herbicides. We share this responsibility with industry, and we greatly appreciate their service and cooperation in developing and proposing appropriate common names which many companies, but alas not all, show on their labels. More widespread adoption of this practice would alleviate many of our present problems. Prominent display of common names on the label of products makes it easier for the purchaser to buy the recommended herbicide.

Why do common names differ among various countries? Progress in reducing this problem is being made. In the past, we in the United States adopted many number-letter abbreviations for herbicides. Some foreign countries will accept only common names (with a few exceptions). For such herbicides as IPC, CIPC, DNBP, NPA, and others, Americans have long used, and still use, the widely recognized letter designations. Our British colleagues have assigned names instead. Somewhat arbitrarily, we have believed that the present widespread use of letter designations offsets the advantages of changing over to common names. Development of multiple common names for a single herbicide also has resulted from instances when a company has released a trademark name as common name in the United States but maintained it as a trademark name in foreign countries. Since the scientists in foreign countries do not wish to use a trademark name in the literature, etc., they are forced to develop another common name differing from the one we have adopted. We hope that, in the future, we shall have few, if any, such cases.

A number of organizations deal with terminology, nationally and internationally. Encouraging progress is being made by joint effort to standardize terminology on an international basis. Groups involved with the problem are: (a) terminology committees of professional societies; (b) national standards organizations, such as ASA, and (c) the International Organization for Standardization. These separate organizations are interrelated and work together. For example, in addition to serving as Chairman of the WSA Terminology Committee, I represent WSA at the American Standards Association Sectional Committee K62, Common Names for Pest Control Chemicals (ASA K62). The U. S. Department of Agriculture accepted the ASA invitation to assume sponsorship for the ASA K62 Committee in 1954 (Haller). ASA K62 is made up of representatives of professional societies and representatives of industrial groups. Common names for pesticides are sponsored by companies or others to the ASA K62 Committee for consideration and approval.

Parallel national standards groups, such as the British Standards Institution and the Canadian Standards Association, have been formed in many of the foreign countries to consider and approve standard common names for pesticides, including herbicides.

The International Organization for Standardization Technical Committee 81, Common Names for Pesticides, (ISO/TC 81), made up of 14 active participating countries and 20 observer member countries, provides international liaison to avoid multiple names for individual pesticides.

I had the privilege of serving as leader of the ASA K62 delegation that participated in the ISO/TC 81 meetings held in London in September 1963. We gained an appreciation of both the problems and the progress and decided that ASA K62 participation in ISO should continue. Considerations necessary for the broad acceptance of common names can be time-consuming and frustrating. The activities of ISO/TC 81 do not automatically dispel all problems in international nomenclature, but we believe good progress is being made. Our recent exchange of ideas with foreign countries, early in the consideration of common names for herbicides, results in names for the most part acceptable internationally.

Some people interested in weed science have different opinions regarding need for certain terminology policies. Because of the many ramifications of this subject, it is not always possible to reach complete agreement among all parties. I suppose this is inevitable. We sincerely attempt to consider the different viewpoints or at least to reach satisfactory compromises. Eventually a decision must be made. Hopefully, such decisions are for the common good of weed science.

Standardized terminology serves a purpose only if it is used. We urge all workers in weed science to make a greater effort to gain widespread adoption and use of approved terminology. If they do, progress in communication will result. But if we continue to ignore the question in speaking, in our recommendations and in our technical papers, communication will continue to suffer and weed science will be retarded. What is done by individuals, even on the local level, has its impact on the whole field.

Literature Cited

H. L. Haller, 1959. Common Names - Aid in Communication. The Magazine of Standards 30:172-174.

EFFECT OF POST-EMERGENCE APPLICATION OF PYRAZON ON YIELD AND WEED CONTROL IN RED BEETS, 1964.

C. B. Sayre[1/], S. A. Anderson[2/], and R. F. Becker[3/].

For red beets a good post-emergence chemical weed control is needed if no pre-emergence treatment is used; or when a pre-emergence treatment with Solubor or with Vegadex fails due to adverse weather conditions. In some preliminary tests in 1963, Pyramin appeared promising for this purpose. Therefore, in 1964 experimental plots were established at two locations (A and B) near Gorham, New York. Each experiment was superimposed in a commercial beet field that had been planted and cultivated with power equipment. They received the regular commercial cultural practices from planting to harvest.

Methods

Experiment A was located on Lima silt loam soil. Detroit Dark Red beets were planted on May 11 with no pre-emergence weed control application. The post-emergence Pyramin treatments were applied on May 29 when the beets were in the first two true leaf stage and weeds were just emerging. The soil was moist below the surface, and the surface was barely moist. Air temperature was 45°F. at time of treatment and the sky was overcast.

Experiment B was located on Lima fine sandy loam soil. Detroit Dark Red beets were planted on May 12 with a pre-emergence weed control application of Solubor in a 4- to 6-inch band over the row. Pyramin treatments were applied on June 2 when the stage of growth of beets and weeds were the same as in Experiment A. Soil moisture conditions were also similar but the air temperature was warmer (62°F.) and the sky was overcast.

The plots in each experiment were 6 feet wide (3 rows) and 30 feet long and were randomly replicated three times. The treatments were applied overall with a knapsack sprayer, using 30 lbs. pressure with a 6-foot boom. Beet stand counts were taken in identical areas three times in each plot; (1) just prior to application, (2) two weeks after application, and (3) at harvest time.

Weed control and crop injury ratings were made twice, 2-3 weeks after spraying. The three authors made their ratings independently and the average of their ratings is given in Table 1. It should be noted that there was very close correlation between the three ratings. Weeds were removed from all plots after these visual observations were completed so as to ensure that any differences in yield or size grades would be due to the effect of the Pyramin treatments on the crop growth.

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For the yield records, 20 feet of the center row of each plot were harvested and topped and the roots were graded in a parallel bar grader to determine the percentage of each size grade.

Results

Table 1 presents the stand counts at three stages of growth, the weed control, and crop injury ratings, and the total yields and size grades. Each figure in Table 1 is the average of three replicates of each treatment in each experiment. There was no visible effect of the Pyramin treatments until 7 days after application.

In Experiment A the 8-lb. rate of Pyramin gave very impressive weed control. The large population of redroot pigweed was practically eliminated by this treatment. However, lambsquarter did not appear to be affected. The heavier application of Pyramin caused a slight stunting of the beets, from which they soon recovered, as shown by the crop ratings on June 9 and June 16, Table 1; and there was no reduction in the stand or yield of beets. The 4-lb. rate of Pyramin was less effective in controlling weeds and showed no effect on the growth of the beets.

Experiment B showed that the 8-lb. rate again gave excellent weed control. Considerable stunting of the beets was noted on June 9 and was more pronounced on June 16; but they eventually recovered. Pyramin at the 4-lb. rate gave fair weed control and very little crop injury. Lambsquarter was not eliminated by Pyramin; but redroot pigweed and ragweed were controlled at the 8-lb. rate. It can be seen in Table 1 that there was no reduction in the stand of beets from using Pyramin at either rate; and as in Experiment A, there was no significant effect on total yield nor the percentage of beets in each size grade.

The largest yield in Experiment A was obtained where Pyramin had been applied at 8 lbs. per acre; and the 4-lb. rate also outyielded the check plot. But, in Experiment B, the order of yields was reversed; the check plot giving the highest yield and the 8-lb. Pyramin treatment the lowest yield; but in each experiment the differences were not significant.

Conclusions

Pyramin at 8 lbs. per acre applied as an overall spray after emergence of red beets and when the weeds were very small or just emerging, gave excellent control of annual weeds with no significant effect on stand, yield, or size grades of beets. At 4 lbs. per acre, Pyramin did not give adequate weed control. Because of temporary stunting of the beets at the 8-lb. rate and lack of commercially acceptable weed control at the 4-lb. rate, the authors conclude that further testing at intermediate rates is desirable.

Acknowledgments

The cooperation of the following growers is gratefully acknowledged: Mr. D. McNamara, Stanley, N. Y.; and Mr. K. Brizzee, Geneva, N. Y.

Table 1. Effect of Post-Emergence Application of Pyramin on Yield and Weed Control in Beets, 1964[1/].

Treatment	Beet Seedlings per foot			Weed Control[2/]		Crop Injury[3/]		Total Yield Tons/acre	Grade Per Cent[4/]		
									Size 1	Size 2	Size 3
					Experiment A						
On -	5/27	6/11	8/18	6/9	6/16	6/9	6/16				
Pyramin 4#	24	24	20	6.0	3.8	9.0	9.0	14.93	47	50	3
Pyramin 8#	23	22	18	7.5	6.6	7.3	8.6	16.31	46	50	4
Check	23	25	20	1	1	9	9.0	14.81	50	45	5
					Experiment B						
On -	6/2	6/16	8/11	6/9	6/16	6/9	6/16				
Pyramin 4#	24	22	17	6.3	6.5	7.3	7.3	11.58	45	49	6
Pyramin 8#	29	25	18	7.9	8.0	5.7	4.7	11.32	46	52	2
Check	24	23	18	1	1	9	9	12.08	49	46	5

1/ Each figure is the average of 3 replicates.

2/ Rated 1-9 where 1 equals no weed control and 9 equals complete weed control. Acceptable commercial weed control is approximately 6.5 to 7.0.

3/ Rated 1-9 where 1 indicates complete crop kill, and 9 indicates no crop injury.

4/ Size 1 = 1" to 1-3/4"; Size 2 = 1-3/4" to 2-1/2"; Size 3 = 2-1/2" to 3-1/4"; Size 4 = over 3-1/4".

EVALUATION OF SEVERAL HERBICIDES FOR BARNYARDGRASS CONTROL IN LIMA BEANS AND SNAP BEANS

T. C. Ellwanger and E. M. Rahn[1]

Barnyardgrass (Echinochloa crusgalli (L.) Beauv.) is a serious weed in the production of snap beans and lima beans in Delaware. This grassy weed reduces crop yields and decreases profits by slowing harvest operations and by damaging harvest equipment. As barnyardgrass plants produce many seeds which exhibit dormancy and the ability to remain viable in the soil for a period of years, the best immediate remedy for this problem is to find a selective herbicide.

PROCEDURE

On June 11, 1964, Thaxter lima beans and Harvester snap beans were planted in 75 ft. plots consisting of one row of snap beans and one row of lima beans with rows spaced 3 ft. apart. There were three replications of each plot set up in a randomized block design. Beans were planted 1½ in. deep with barnyardgrass seeded over the row at ½ in. depth. The soil was a Matapeake loam and was naturally heavily infested with broadleaf weeds, principally redroot pigweed (Amaranthus retroflexus L.). On the date of planting this soil was very dry. Pre-plant incorporated materials were applied on the day of planting and incorporated to a depth of 4 inches with a disk. Materials incorporated just after planting were worked into the soil with a rod weeder. All materials used were applied with a logarithmic sprayer using 100 gal. water/A. as a carrier. Post-emergence treatments were applied on July 1, when the beans' first trifoliate leaves were fully expanded.

Plots were irrigated three times at two-week intervals beginning on June 15, applying 1 in. on a given date.

Weed control ratings were recorded on July 6, 20, Aug. 5 (when snap beans were harvested), and Sept. 9 (when lima beans were harvested).

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Maximum Rate of Herbicide Tolerated by Lima Beans and Snap Beans and Minimum Rates Needed for Barnyardgrass and Broadleaf Weed Control[1]

Herbicide and Rate, lb/A		Method of Application	Max. Rate (lb/A) Tolerated by Snaps	Limas	Min. Rate (lb/A) Required for Grass Control	Bd.Leaf Control
EPTC	10.0-1.5	Po.-Plt.Inc.[2]	10.0	--	3.1	1.8
Amiben	10.0-1.5	Pre.-emer.[3]	--	10.0	2.1	1.9
Linuron	4.0-0.6	Pre.-emer.	3.7	3.7	1.4	0.9
Trefmid	15.0-2.3	Pre.Plt.Inc.[4]	15.0	15.0	6.0	7.2
Trefmid	15.0-2.3	Po.-Plt.Inc.	15.0	15.0	3.8	3.8
Tupersan	10.0-1.5	Pre.-emer.	10.0	10.0	2.0	6.3
Tupersan	10.0-1.5	Po.-emer.[5]	10.0	10.0	4.1	8.7
Tenoran	5.0-0.8	Po.-emer.	1.4	2.3	4.7	1.6

1. Rating of July 20, 1964.
2. Post-plant incorporated.
3. Pre-emergence.
4. Pre-plant incorporated.
5. Post-emergence, applied July 1, 1964.

RESULTS

For lima baans the most effective herbicides for barnyardgrass control, along with their effective ranges, were as follows: amiben, 2.1-10.0 lb/A.; linuron, 1.4-3.7 lb/A.; Trefmid (post-plant incorporated), 3.8-15.0 lb/A.

Effective materials on snap beans and their respective ranges for barnyardgrass control were as follows: EPTC, 3.1-10.0 lb/A.; linuron, 1.4-3.7 lb/A.; Trefmid (post-plant incorporated), 3.8-15.0 lb/A.

At the above rates, natural occurring broadleaves were also controlled in both lima beans and snap beans.

THE RESPONSE OF SNAP- AND LIMA BEANS TO PRE-PLANT AND PRE-EMERGENCE TREATMENTS

R. D. Ilnicki, W. H. Tharrington, J. F. Ellis and E. J. Visinski[1]

In New Jersey, approximately 8,000 acres of lima and snap beans are grown for fresh market use. The annual value of these crops is approximately two million dollars. Because of their importance in New Jersey agriculture, research in weed control has been conducted on these crops for the past four years.

At present, two herbicides are recommended for pre-emergence weed control in these crops in New Jersey. These are 4,6-dinitro-2-sec. butylphenol (DNBP) and dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA). These have proved adequate but their short residual behavior or failure to control certain weeds has stimulated the quest to discover better herbicidal treatments for more efficient weed control.

Pre-emergence applications of ethyl N,N-di-n propylthiolcarbamate (EPTC) and 3-amino-2,5-dichlorobenzoic acid (amiben) are some of the commonly used herbicides that have proved successful. More recently the pre-plant soil-incorporated method of application has proved to be superior to the pre-emergence method with regard to certain types of herbicides. Ease of application, increase in herbicidal efficiency, and decrease of environmental effects upon herbicide activity are the advantages of the pre-plant over the pre-emergence method.

Materials and Methods

Experiments on snap- and lima beans were conducted at the Adelphia Research Station of the New Jersey Agricultural Experiment Station. For the sake of brevity treatments, varieties, dates of planting, application, ratings, and harvest, and soil type are presented in Tables 1 and 2 for snaps and limas, respectively.

Spray applications were applied with a well-calibrated knapsack sprayer in water dilutions of 40 gpa. Granular preparations were applied with a hand applicator with measured amounts for each plot. Pre-plant applications were made to previously

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designated plot areas then incorporated with a spring-tooth harrow to a depth of 3 to 4 inches. Post-planting pre-emergence treatments that required incorporation were made using a potato rake to simulate harrowing.

All experiments were designed as randomized complete blocks with three replications.

Immediately after the application of herbicides, the experimental areas were irrigated with one acre-inch of water. The areas were subsequently irrigated as needed for a total of three times.

Weed control was evaluated by three individuals independently of each other using a scale 0 to 10 as indicated in Tables 1 and 2.

Yields were determined from harvests of the two center rows of the four-row plots which were 16 feet in length.

Results and Discussion

Summaries of weed control, crop response, and yields are presented in Tables 1 and 2 for snap and lima beans, respectively.

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

Snap Beans

Trifluralin, applied as pre-plant soil incorporated treatments, was the single outstanding herbicide with regard to weed control and crop safety. Combinations with diphenamid were also good treatments. R-1607 was also a good herbicide both for grasses and broadleaves. The emulsifiable concentrate was safer than the granular preparation. A rate of 4 lb/A of R-1607 is more than adequate while rates of 1/2 to 1 lb/A of trifluralin are sufficient for commercial weed control.

Not withstanding that the pre-plant application as a method was superior to the pre-emergence method, there were some outstanding pre-emergence herbicides. These included, of the older herbicides, the following: NPA + CIPC, amiben, and diphenamid. It is worthy of note that the combination of NPA + CIPC at 2 + 2 lb/A was more effective than the combination of 2 + 1.3 lb/A (commercial) especially for the control of grassy weeds. Amiben spray was more effective than the amiben granular. Diphenamid again proved effective for weed control in snap beans.

The combination of amiben + CIPC was less effective when lightly incorporated than where not incorporated. This is the reverse of what results when the application is not followed by irrigation. Under dry conditions incorporating this mixture

Of the new compounds studied for the first time, SD 9515 at rates of 4 to 8 lb/A, CP 31393 at 4 to 6 lb/A, UC 22463 at 4 to 6 lb/A, and Bayer 56250 at 6 lb/A appear promising for weed control in snap beans.

Of particular interest was the control of nutsedge (cyperus esculentus) with pre-emergence applications of CP 31393 at rates of 4 and 6 lb/A.

Lima Beans

As with snap beans, trifluralin was the outstanding herbicide for weed control in limas. A rate of 1 lb/A is sufficient for weed control with no crop injury when applied prior to planting and incorporated into the upper soil surface. Combinations of trifluralin and diphenamid are also effective for weed control; however, a slight increase in the rate of trifluralin alone produces just as good weed control as the addition of diphenamid to the mixture.

R-1607 was an effective herbicide but effected some loss of stand and produced some early stunting. Generally, limas are more sensitive to thiolcarbamate herbicides than snap beans. The greater effectiveness of the emulsifiable over the granular is exemplified in lima bean injury as well as weed control. Rates above 4 lb/A become a risk with R-1607.

Outstanding pre-emergence herbicides included SD 9515 at 4 to 8 lb/A, tenoran at 8 lb/A, Bayer 56250 at 2 and 4 lb/A, CP 31393 at 2 to 6 lb/A, trifluralin + diphenamid at 1 + 4 lb/A, UC 22463 at 6 lb/A, NPA + CIPC at 2 to 3 + 2 lb/A, and amiben. Granular amiben was slightly inferior to liquid amiben.

Combinations of NPA with DNBP and amiben with CIPC appear to have merit for weed control in lima beans with little or no injury to the crop.

Generally, those herbicides which performed well in snap beans performed well on lima beans. With regard to sensitivity limas are generally more sensitive to herbicidal treatments than snap beans.

Summary

Many herbicides were evaluated for weed control in snap and lima beans.

Pre-plant applications of certain types of herbicides appear to hold much promise for weed control. Pre-plant soil incorporated treatments effected better weed control than pre-emergence treatments

Trifluralin was the outstanding pre-plant herbicide. Other herbicides, applied pre-emergence, included SD 9515, CP 31393,

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

Variety - Henderson Bush
Planted - June 10
Treated - June 10 - 12
Rated - July 2[1]

Harvested - July 28 - 30
Location - Adelphia, New Jersey
Soil Type - Freehold Sandy Loam

		Weed Control				Crop Response		
		Broadleaves		Grasses				
Treatment	Rate, lb/A	Stand[2]	Vigor[3]	Stand[2]	Vigor[3]	Stand[2]	Vigor[3]	Crop Yield lb/A
Pre-plant soil incorporated								
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), 4 lb/gal	1/2	7.8	0.7	6.7	1.3	0.8	0.6	4513
	1	9.0	1.4	8.6	1.1	0.3	0.0	5046
	2	9.5	3.1	8.4	2.9	0.1	0.0	5469
n-Propyl di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
	3	9.1	3.2	9.1	3.8	0.8	1.1	4162
	5	9.9	9.9	9.9	9.1	0.9	5.2	3110
5G	3	8.2	1.1	8.7	2.3	0.4	0.7	4162
	5	9.1	2.3	9.4	3.8	0.5	3.1	4356
Trifluralin + N,N-dimethyl-2,2-diphenylacetamide (diphenamid)								
	1/2+2	7.3	1.0	6.6	1.3	0.1	0.1	5481
	1+4	8.9	1.0	7.7	1.2	0.0	0.1	5566
Check - uncultivated								
	-	0.6	0.0	1.2	0.0	0.1	0.1	3872
L.S.D. 0.05								1384
Post plant pre-emergence								
4-Chloro-2-nitrophenyl methyl sulfone (SD 9515), 50W								
	2	2.6	0.8	5.1	3.8	0.7	0.4	2287
	4	9.6	1.0	9.2	3.6	0.1	0.2	3352
	8	9.1	3.0	9.6	7.0	0.7	0.8	2202
N-4-(p-Chlorophenoxy)-phenyl-N',N'-dimethylurea (Tenoran), 50W								
	2	3.7	0.8	3.8	1.1	0.1	0.1	2275
	4	5.5	0.9	5.4	0.8	0.4	0.2	2202
	6	7.2	1.1	7.3	2.3	0.0	0.3	3860
4,5,7-Trichlorobenzthiadiazole-2,1,3 (TH-052-H), 50W								
	4	4.6	1.1	4.4	1.1	0.7	0.4	2989
	6	5.4	1.1	5.1	1.3	1.4	0.7	2505
2,4-Dinitrophenyl(2'-sec.butyl-4',6'-dinitrophenyl) carbonate (B-377), 3lb/gal	1 1/2	9.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response Stand[2]	Crop Response Vigor[3]	Crop Yield lb/A
2-Isopropylamino-4-methoxyethylamino-6-methylmercapto-s-triazine (G-36393), 25W								
	2	1.4	0.3	2.2	0.3	0.4	0.3	1839
	4	4.9	1.1	5.8	1.2	0.2	0.3	2190
Bayer 55967 (Chemistry undisclosed) 25% E.C.								
	4	8.8	1.1	6.8	2.2	3.6	5.9	617
	6	9.6	6.1	9.8	7.0	6.7	9.8	1029
Bayer 56250 (Chemistry undisclosed) 30% E.D.								
	2	6.4	1.0	6.8	1.4	1.1	1.1	2747
	4	8.3	2.6	9.0	3.3	1.6	1.3	2602
N-Isopropyl-a-chloroacetanilide (CP 31393), 65W								
	2	5.9	2.2	6.7	2.6	0.3	0.3	2856
	4	7.9	1.8	7.8	3.1	0.3	0.6	3279
	6	9.7	6.9	8.7	6.0	0.0	0.2	3666
2,4-Dichlorophenyl-4-nitrophenyl ether (FW 925)								
	4	2.6	0.0	5.8	0.5	2.1	1.3	980
	6	6.4	1.4	6.4	3.3	2.3	1.9	1416
Trifluralin + diphenamid								
	1/2+2 inc.	6.0	1.8	6.4	2.4	0.7	0.7	2964
	1+4	5.9	1.8	6.2	3.0	0.7	0.2	3896
BV 201 (Chemistry undisclosed) 2 lb/gal								
	2	0.6	0.1	1.3	0.1	0.1	0.1	2432
	4	1.6	0.5	1.7	0.5	0.0	0.1	2480
	6	5.1	1.6	5.0	1.4	0.0	0.2	3170
3,4-Dichlorobenzyl-N-methylcarbamate (UC-22463A), 4 lb/gal								
	2	6.5	1.0	6.1	1.1	0.2	0.1	2493
	4	7.4	2.7	7.3	3.2	0.4	0.2	3109
	6	9.0	2.8	9.4	4.8	0.9	0.3	3770
OCS-21944 (Chemistry undisclosed)								
	2	5.0	1.5	6.4	3.9	0.4	0.3	2057
	4	3.4	1.0	4.1	2.1	0.6	0.6	2819
	6	2.9	0.8	3.8	1.3	0.2	0.1	2517
N-1-Naphthylphthalamic (NPA), 2 lb/gal + isopropyl-N-(3-chlorophenyl) carbamate (CIPC), 4 lb/gal								
	2+2	7.6	0.8	7.7	1.0	0.3	0.3	3206
	3+2	9.2	2.6	8.3	1.8	0.3	0.4	2008
	2+1.3[4]	7.5	2.2	4.9	2.8	0.3	0.3	2166
NPA + 4,6-dinitro-2-sec. butylphenol (DNBP)								
	2+1[4]	8.8	3.3	6.0	2.8	0.4	0.4	2335

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response Stand[2]	Crop Response Vigor[3]	Crop Yield lb/A
3-Amino-2,5-dichlorobenzoic acid (amiben) + CIPC								
	1-1/2+3	8.8	1.9	8.3	3.6	0.4	0.3	3896
	1-1/2+3[5]	5.8	2.7	7.4	3.3	0.6	0.7	2880
Amiben, 2 lb/gal								
	3	9.1	6.5	9.7	6.4	0.9	0.9	3642
10G	3	8.5	4.3	8.6	4.8	0.8	0.8	2964
Diphenamid, 50W								
	2	7.2	2.6	5.2	1.7	0.3	0.1	3376
	4	8.2	4.1	7.0	3.3	0.2	0.6	4066
GS-17269 (Chemistry undisclosed), 50W								
	2	0.4	0.4	0.2	0.0	0.1	0.0	2287
	4	1.8	0.6	2.4	0.2	0.2	0.6	2069
2,4-bis (Isopropylamino)-6-methylmercapto-s-triazine (prometryne), 80W								
	2	2.9	1.5	3.0	1.3	0.6	0.3	2831
	4	6.6	1.6	6.8	3.6	3.9	0.2	3146
Checks - uncultivated								
	-	1.9	0.6	2.7	0.4	0.6	0.7	1452
	-	0.1	0.1	0.1	0.1	0.3	0.0	1876
	-	1.2	0.1	2.9	0.6	0.3	0.1	1367
L.S.D.	0.05							1026

[1] Average of three replications and three ratings per replication.

[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.

[4] Commercial mixture.

[5] Shallow incorporation.

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

Variety - Thaxter
Planted - June 10
Treated - June 10 - 12
Rated - July 2[1]

Harvested - August 24 - 25
Location - Adelphia
Soil Type - Freehold Sandy Loam

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response Stand[2]	Crop Response Vigor[3]	Crop Yield lb/A
Pre-Plant soil incorporated								
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), 4 lb/gal	1/2	5.1	0.8	6.6	1.2	1.2	0.4	3073
	1	7.0	1.9	9.1	4.0	0.6	0.4	3049
	2	7.9	2.1	9.9	3.8	0.3	0.8	4852
n-Propyl di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
	3	7.9	2.6	8.5	4.4	2.3	2.4	2565
	5	9.1	5.0	9.9	9.9	4.4	4.9	908
5G	3	6.6	2.4	8.2	4.1	0.9	1.8	3013
	5	7.9	2.7	9.1	4.3	2.3	2.9	2565
Trifluralin + N,N-dimethyl-2,2-diphenylacetamide (diphenamid)								
	1/2+2	6.1	3.3	8.7	4.9	0.2	0.1	3473
	1+4	9.1	1.7	6.1	3.0	0.1	0.1	3480
Check - uncultivated								
	-	0.0	0.0	0.0	0.0	0.0	0.0	1234
L.S.D. 0.05								1375
Post plant pre-emergence								
4-Chloro-2-nitrophenyl methyl sulfone (SD 9515), 50W								
	2	6.4	1.8	5.6	2.6	1.3	0.9	1609
	4	7.1	2.0	8.0	4.3	1.2	0.9	4453
	8	8.5	5.1	9.2	7.1	0.3	0.2	4356
N-4-(p-Chlorophenoxy)-phenyl-N'-N'-dimethylurea (tenoran), 50W								
	2	5.3	1.0	3.2	1.1	0.7	0.1	1863
	4	6.7	3.5	3.5	2.2	0.6	0.6	2614
	6	7.8	3.4	3.8	2.0	0.4	0.3	3049
4,5,7-Trichlorobenzthiadiazole-2,1,3 (TH-052-H), 50W								
	4	6.2	3.2	5.0	3.0	0.6	0.4	2081
	6	5.7	2.8	6.0	2.9	0.4	0.3	2166

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response Stand[2]	Crop Response Vigor[3]	Crop Yield lb/A
2,4-Dinitrophenyl ('-sec. butyl-4',6'-dinitrophenyl) carbonate (B-377)								
3 lb/gal	1-1/2	1.2	0.4	1.4	0.2	0.3	0.2	920
	3	3.1	0.9	1.0	0.4	0.4	0.1	1041
2-Isopropylamino-4-methoxyethylamino-6-methylmercapto-s-triazine (G-36393), 25W								
	2	1.9	0.3	0.6	0.3	0.4	0.2	1150
	4	4.2	1.7	5.1	2.0	0.9	0.1	1779
Bayer 55967 (Chemistry undisclosed), 25% E.C.								
	4	8.9	6.3	7.2	4.1	2.9	5.2	2432
	6	8.5	5.8	7.1	9.0	5.1	7.7	520
Bayer 56250 (Chemistry undisclosed), 30% E.C.								
	2	5.5	2.8	7.1	2.1	0.9	0.2	2105
	4	7.3	4.1	6.6	2.9	1.7	1.1	2856
N-Isopropyl-a-chloroacetanilide (CP 31393), 65W								
	2	7.3	3.8	7.4	4.0	0.2	0.1	2626
	4	9.3	6.1	9.2	5.8	0.6	0.3	3545
	6	10.0	10.0	10.0	10.0	0.5	0.5	3787
2,4-Dichlorophenyl-4-nitrophenyl ether (FW 925)								
	4	6.0	2.3	5.3	2.1	2.3	1.1	714
	6	6.1	2.3	7.1	3.6	3.3	1.3	1827
Trifluralin + diphenamid								
	1/2+2 inc	6.0	4.0	5.2	3.7	0.2	0.2	2226
	1+4	7.2	4.7	8.0	4.2	0.6	0.2	3388
BV 201 (Chemistry undisclosed), 2 lb/gal								
	2	5.1	3.1	4.9	1.5	0.6	0.2	2335
	4	2.5	2.2	3.1	1.6	0.7	0.3	1284
	6	5.4	3.6	4.5	3.0	3.0	1.1	1331
3,4-Dichlorobenzyl-N-methylcarbamate (UC 22463A), 4 lb/gal								
	2	4.6	2.2	6.3	2.4	0.9	0.3	1984
	4	5.0	3.0	7.2	2.9	0.6	0.4	3134
	6	8.6	5.4	8.2	6.2	0.4	0.3	5179
OCS-21944 (Chemistry undisclosed)								
	2	3.5	1.6	5.8	2.2	0.3	0.3	1525
	4	4.3	2.3	5.8	2.3	0.8	0.6	1755
	6	5.6	3.9	7.2	3.2	0.6	0.5	2468

Treatment	Rate lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response: Stand[2]	Crop Response: Vigor[3]	Crop Yield lb/A
N-1-Naphthylphthalamic acid (NPA), 2 lb/gal + isopropyl-N-(3-chlorophenyl) carbamate (CIPC), 4 lb/gal								
	2+2	9.5	4.3	7.2	3.4	0.8	0.7	3279
	3+2	8.5	4.7	7.0	4.0	0.9	0.8	3061
	2+1.3[4]	7.7	4.0	5.5	3.2	1.0	1.5	2429
NAP + 4,6-dinitro-2-sec. butylphenol (DNBP)								
	2+1[4]	8.8	6.7	7.1	0.4	0.9	1.6	2432
3-Amino-2,5-dichlorobenzoic acid (amiben) + CIPC								
	1-1/2+3	8.7	6.1	7.4	5.1	0.3	0.2	3884
	1-1/2+3[5]	7.1	3.3	7.0	2.9	1.2	1.0	2214
Amiben, 2 lb/gal								
	3	8.8	5.3	8.9	5.8	0.8	0.6	6679
10G	3	7.3	3.5	8.3	3.5	1.1	1.1	4719
Diphenamid, 50W								
	2	6.3	3.4	7.1	4.0	0.6	0.3	4828
	4	7.7	5.2	7.7	3.8	0.4	0.3	3775
GS-17269 (Chemistry undisclosed), 50W								
	2	2.9	2.7	1.5	1.1	0.9	0.4	1863
	4	4.8	2.3	2.8	1.9	0.6	0.4	2541
2,4-bis (Isopropylamino)-6-methylmercapto-s-triazine (prometryne), 80W								
	2	3.6	1.6	3.2	1.2	0.3	0.1	1585
	4	6.9	3.4	7.0	3.3	0.9	0.7	2226
Checks - uncultivated								
	-	1.7	0.8	1.1	0.8	0.4	0.5	1428
	-	2.2	1.4	2.3	1.6	0.3	0.3	1379
	-	1.4	1.1	0.1	0.4	0.4	0.2	1004
L.S.D.	0.05							611
	0.01							810

[1] Average of three replications and three ratings per replication.

[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.

[4] Commercial mixture.

[5] Shallow incorporation.

CHEMICAL WEEDING OF BEETS AND CARROTS

Charles J. Noll[1]

This is a report on the chemical weeding of beets and carrots and the continuation of work started a number of years ago. Although several herbicides are recommended for the weeding of these two crops, promising new herbicides have been reported that warrant further investigation.

Procedure

In general, beet and carrot trials are similar. The seedbeds were prepared, and pre-planting herbicide treatments applied and incorporated May 11th. Beet variety, Detroit Dark Red, and Carrot variety, Chantenay Red Cored were seeded May 12th. Single row plots were 18 feet long with 2 feet between rows. Treatments were randomized in each of 6 blocks. All chemicals were applied in a 2 foot band over the row.

Cultivation controlled the weeds between the rows. An estimate of weed control was made June 24. A rating of 1 to 10 was used, 1 being most desirable and 10 least desirable. Beets were harvested July 21 and carrots August 26.

Results and Conclusions

The results are presented in Tables I and II. In the beet trial, taking into consideration weed control, stand of plants and weight of roots, the best treatments are: pyrazon at 8 lbs. per acre applied pre-emergence 1 or 6 days after seeding or post-emergence 15 days after seeding and the combination of pyrazon at 4 lbs. per acre with 4 lbs. of Tupersan per acre or with 3 lbs of CP 31393 applied 6 days after seeding.

In the carrot trial, taking into consideration weed control, stand of plants and weight of roots, the best treatments are: trifluralin at 2 pounds per acre incorporated in the soil a day ahead of planting; amiben at 8 lbs., TOK at 6 lbs. and Tupersan at 6 pounds per acre applied as a pre-emergence treatment 2 days after seeding; solan at 6 lbs. per acre applied as a post-emergence treatment 37 days after seeding and the combination treatment of CIPC at 6 lbs. per acre applied 2 days after seeding followed by Stoddard Solvent at 70 gal. per acre applied 29 days after seeding.

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Table I. Weed Control, stand of plants and weight of roots of beets under chemical herbicide treatment

Treatment	Active Rate per Acre lbs	Application Day from Planting	Average per Plot *Weed Control (1-10)	Stand of Plants	Weight of Beets lbs
1 Nothing	-	-	8.7	39.0	3.9
2 Hand weed	-	-	1.0	33.5	5.6
3 Pyrazon	4	Inc. - 1	3.3	27.0	4.3
4 Pyrazon	8	" - 1	2.0	18.5	3.6
5 EID 634	2	" - 1	2.5	10.0	1.5
6 EID 634	3	" - 1	1.7	7.0	0.9
7 Pyrazon	4	Pre-e + 0	5.3	33.0	4.4
8 Pyrazon	8	" + 0	3.3	33.8	6.1
9 RC3056	3	" + 0	5.3	30.7	3.7
10 RC3056	6	" + 0	4.3	27.3	4.3
11 TD 570	3	" + 0	6.0	32.5	3.1
12 TD 570	6	" + 0	6.0	33.3	4.0
13 TD 291	3	" + 0	7.5	24.0	2.5
14 TD 291	6	" + 0	6.0	33.7	4.8
15 ACP 64-84	2	" + 0	5.9	23.8	3.1
16 ACP 64-84	3	" + 0	5.2	33.0	4.1
17 Pyrazon	4	Pre-e + 6	4.7	34.3	5.0
18 Pyrazon	8	" + 6	3.2	45.3	7.7
19 Endothall + TCA	6 + 10	" + 6	1.7	34.8	4.9
20 OCS 21944	2	" + 6	7.7	14.7	1.0
21 OCS 21944	4	" + 6	6.7	3.2	0.2
22 OCS 21944	6	" + 6	5.3	1.7	0.1
23 OCS 21944 + Pyrazon	4 + 4	" + 6	4.9	1.2	0.1
24 Tupersan	6	Pre-e + 6	4.0	33.2	6.1
25 Tupersan + Pyrazon	4 + 4	" + 6	3.5	37.3	6.3
26 Tenoran	4	" + 6	6.5	0.5	0.1
27 Tenoran + Tupersan	2 + 6	" + 6	4.5	12.0	2.4
28 TCA + Pyrazon	10 + 4	" + 6	5.3	29.2	3.8
29 TOK + Pyrazon	4 + 4	" + 6	2.0	29.2	4.5
30 CP 31393 + Pyrazon	3 + 4	" + 6	1.0	33.0	7.0
31 TCA	10	" + 6	7.7	28.2	3.7
32 RC 3056 + TCA	6 + 10	" + 6	5.0	26.8	3.7
33 Cycluron + DNBP	1 + 1	" + 6	4.3	17.7	2.5
34 Pyramin	4	Post-e + 15	3.7	37.3	5.5
35 Pyramin	8	" + 15	2.9	41.8	6.3
Least significant difference	5%		2.0	12.6	2.0
Least significant difference	1%		2.6	16.6	2.6

Table II. Weed Control, stand of plants and weight of roots of carrots under chemical herbicide treatment

Treatment	Active Rate per Acre lbs.	Application Day from Planting	Average per Plot *Weed Control (1-10)	Number of Roots	Weight of Roots lbs.
1 Nothing	-	-	8.5	49	2.3
2 Trifluralin	2	Inc - 1	1.0	49	7.5
3 R-4461 (Betasan)	10	" - 1	2.5	59	4.7
4 EID 634	2	" - 1	1.2	0	0
5 Prometryne	3	Pre-e + 2	1.0	24	3.9
6 DCPA (Dacthal)	10	" + 2	6.2	53	3.8
7 DCPA	20	" + 2	5.3	39	2.6
8 Amiben	4	" + 2	5.2	52	3.7
9 Amiben	8	" + 2	3.3	80	7.8
10 TOK	3	" + 2	4.2	42	3.4
11 TOK	6	" + 2	1.8	61	6.5
12 GS 17269	2	" + 2	6.5	46	2.0
13 GS 17269	4	" + 2	5.5	30	1.6
14 GS 14260	2	" + 2	3.5	37	3.7
15 GS 14260	4	" + 2	1.7	19	2.2
16 Tenoran	4	Pre-e + 2	6.7	30	2.6
17 Tenoran	6	" + 2	6.7	42	2.6
18 Tupersan	4	" + 2	5.5	45	4.0
19 Tupersan	6	" + 2	3.3	59	6.2
20 Tenoran + Tupersan	4 + 4	" + 2	4.0	55	5.8
21 OCS 21944	2	" + 2	4.8	33	2.9
22 OCS 21944 + Tenoran	2 + 4	" + 2	4.8	39	2.4
23 CIPC	6	" + 2	4.3	81	4.7
24 CIPC + Stoddard S.	6 + 70 gal.	Pre-e + 2, & Post + 29	1.5	61	5.9
25 Tenoran + MCPA	4 + 1	Pre-e + 2, & Post + 37	6.0	57	2.9
26 MCPB (EP 238)	1	Post-e + 37	8.0	49	3.2
27 R-4461 (Betasan)	10	Pre-e + 2	7.7	54	2.7
28 Linuron	1	Post-e + 22	1.3	35	4.0
29 Prometryne	2	" + 22	1.0	3	0.2
30 Stoddard Sol.	70 gal.	Post-e + 22	1.3	23	2.4
31 Stoddard Sol.	70 gal.	" + 29	1.7	51	4.8
32 Linuron	½	Post-e + 29	4.2	54	3.8
33 Linuron	1	" + 29	3.2	42	3.5
34 Solan	6	" + 29	2.5	29	3.0
35 Solan	6	" + 37	3.3	74	7.9
Least significant difference 5%			2.2	27	2.6
Least significant difference 1%			2.9	36	3.5

*Weed Control 1-10: 1 perfect weed control
10 full weed growth

EFFECTIVENESS OF LINURON AND PROMETRYNE FOR WEED CONTROL IN CARROTS AS AFFECTED BY CERTAIN ENVIRONMENTAL CONDITIONS

Henry Kuratle and E. M. Rahn[1].

Abstract[2].

Previous experiments have indicated that linuron, (3(3,4-dichlorophenyl)-1-methoxy-1-methyl urea) and prometryne, (2,4-bis(isopropylamino)-6-methylthio-s-triazine) are promising new herbicides for carrots.[1,2] They are superior to the standard herbicide used, Stoddard Solvent, because they are more effective for control of common ragweed, *Ambrosia artemisiifolia*, and because they cost much less and are less hazardous to apply. Experiments reported in this paper were conducted to investigate the effects of certain environmental factors on the effectiveness of pre and post-emergence applications of these herbicides, to find the stage of carrot and weed growth when the chemicals are most effective, and to evaluate the use of a surfactant in post-emergence applications.

In pre-emergence applications, these herbicides were most effective at 2 lbs/A. Carrots were more sensitive to these chemicals when applied just before emergence rather than at seeding. Irrigation just before or after herbicide application, and applying an asphalt soil mulch just after herbicide application, had no effect on weed control but did reduce crop stand. Compacting the soil prior to application of the herbicides reduced weed control.

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2. Abstract of a manuscript to be submitted to Weeds.

3. The authors wish to acknowledge the cooperation of the following companies in supplying the chemicals used in this study: E. I. DuPont de Nemours & Co., linuron; Geigy Chemical Corp., prometryne; and Atlas Chemical Industries, Atlox 209 FG surfactant.

In post-emergence applications, linuron and prometryne gave excellent control of broadleaves at 2 lbs/A. with no significant crop injury at the following stages of carrot growth: 1-2 true leaves and 3 inches. Logged plots indicated however, that at the 6-inch stage of growth carrots were much less tolerant of these herbicides and a rate higher than 2 lbs/A was needed to get effective weed control.

Post-emergence applications applied when the air temperature was greater than 90°F resulted in considerable crop injury whereas no crop injury occurred at an air temperature of 80°F. This crop injury however, was not reflected in significantly reduced yields. Weed control at these two temperatures was equal, but weed kill was much more rapid at the higher temperatures. Linuron gave significantly more crop injury at temperatures greater than 90°F than did prometryne.

Shading, to simulate cloudy weather, before and after applications of these herbicides did not have any effect on weed control, but did affect crop injury. Carrots that had been shaded for 7 days prior to application of these herbicides showed considerable crop injury. This crop injury was not reflected in significantly reduced yields.

Irrigation before and after post-emergence applications of these herbicides had no effect on weed control. However, more crop injury resulted when these herbicides were applied to moist soil.

Adding Atlox 209 FG surfactant to linuron and prometryne increased the effectiveness of post-emergence applications of these herbicides. Indications were that 0.5 percent surfactant by volume and 1 lb/A of either linuron or prometryne was as effective as 2 lbs/A of either herbicide alone. No change in the margin of safety was observed with the addition of Atlox 209 FG surfactant.

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Chemical Weed Control in Transplanted Tomatoes [1/]

J. D. Long and F. C. Stark[2/]

Maryland vegetable growers produce over 10,000 acres of tomatoes annually for a gross income of more than 4 million dollars. The efficient control of weeds is a major problem for most tomato growers. In fact the efficiency and completeness of weed control operations may often determine the margin of profit for the grower. Herbicides, although they might not replace cultivation completely, can improve the efficiency with which good weed control may be obtained in many instances. Various herbicides can be useful when applied prior to planting, immediately following planting, or at lay-by (last cultivation-4 to 6 weeks after planting). The effectiveness of control and safeness to the crop are critical factors to be considered regardless of the time of application.

Materials and Methods

Two studies were conducted to evaluate the use of certain herbicides applied at transplanting and at lay-by. The experiments were conducted on sandy loam at the University of Maryland Vegetable Research Farm, Salisbury, Maryland. The first one-third and last one-third of the 1964 season were very dry. The total rainfall received in May was only 0.40 inches. A one-half-inch rain early in June was followed by two more weeks of dry weather. The remainder of June and all of July had sufficient rainfall. August was again dry with a total of only 0.62 inches. No irrigation was applied. Major weed pests were crabgrass, goosegrass, lambsquarter, ragweed and morning glory in descending order of importance.

Campbell 146 tomatoes were transplanted May 6. Both experiments were arranged in randomized complete block designs with 4 replications. A single plot consisted of 3 rows 64 inches apart with 16 plants per row spaced 22 inches apart. All three rows were treated but only the center row was used for records. The soil surface was dry and soil moisture was low at all times of herbicide application. Six weekly harvests were made beginning July 29. The fruit were graded into combined US No. 1 and 2 canning grades and weighed. Diseases and insects were controlled by weekly sprays.

At Planting Trial

Herbicides were broadcast sprayed with a tractor-mounted sprayer at 50 gpa. Two pre-planting treatments, trifluralin + diphenamid[3/] and trifluralin, were applied late in the evening, May 5, and incorporated 3-4 inches within 15 minutes using a Tilrovator. Two treatments, diphenamid and R 4461,

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1/ Scientific Article No. A1162, Contribution No. 3635 of the Maryland Agricultural Experiment Station, Department of Horticulture.

2/ Research Assistant, University of Maryland Vegetable Research Farm, Salisbury, and Professor of Vegetable Crops, University of Maryland, College Park.

3/ Trefmid 50W (10% trifluralin & 40% diphenamid).

were applied about 8 hours after transplanting during the late evening. The remaining two treatments in this trial were controls. One control treatment consisted of cultivation on June 4, 17, 30 and hoeing on the latter two dates. The cultivated plots were sidedressed with 300 lb/A 8-16-16 on June 4 while all other plots in this trial were topdressed at that time. The second set of control plots were hand-weeded. Weeds were plucked out while small with as little disturbance of the soil surface as possible. Herbicide-treated and hand-weeded plots received no cultivation or hoeing during the season.

Lay-by Trial

All plots were kept essentially weed free by cultivations and hoeings on the same dates as the cultivated check in the trial above. Following the June 30 cultivation and hoeing, 5 herbicides were broadcast over the appropriate plots with a fluted-roller granular applicator (1) set for a constant rate. The control plots were not treated. All plots were then cultivated lightly to incorporate the herbicides to some extent.

Results and Conclusions

None of the herbicides in either trial caused any visible injury to the crop. Yield differences among the treatments were due almost entirely to the competition effect of weeds not controlled by the various herbicides.

At Planting Trial

Pertinent data for treatments applied just before and just after transplanting are presented in Table I. Data represent the means (averages) for 4 replications.

Table I. The effects of herbicides applied prior to or following planting on yield and weed control in transplanted tomatoes.

At Planting Treatment	Lbs AI/A	Weed Control 1/ 6/18	8/6	9/7	Ave. Yield 2/ Tons/Acre
Cultivated Check		10.0	8.8	7.5	14.80 a
Hand Weeded Check		10.0	9.8	8.3	14.65 a
Diphenamid 80W (Post-plant)	4.0	6.5	4.0	3.0	8.18 b
R 4461 4E (Post-plant)	16.0	7.3	3.0	3.0	7.48 b
Trifluralin + diphenamid 3/ (Pre-plant inc.)	2.5	9.5	9.7	9.7	14.03 a
Trifluralin 4E (Pre-plant inc.)	1.0	9.8	9.3	9.5	15.48 a

1/ Rated 0 to 10 (10 represents nearly perfect control)

2/ Means followed by the same letter are not significantly different at 5% level. Coefficient of Variation = 11.02%

3/ Trefmid 50W (10% trifluralin and 40% diphenamid).

Hand Weeded Check. Weeds were pulled while very small. Plots were weeded on 6/4, 6/18, 7/2 and 7/24 with about 2.5 man hours required for each weeding. The yield was not significantly different from the cultivated check. This indicates that any harmful effects of cultivation (i.e. root injury, moisture loss, etc.) were balanced by beneficial effects of cultivation (i.e. aeration, rainfall penetration, fertilizer placement, etc.).

Diphenamid (Post-plant Surface) Diphenamid gave poor control and the yield was reduced to about two-thirds that of the check. This emphasizes the need for mechanical cultivation when diphenamid application is followed by dry weather.

R 4461 (Post-plant Surface) Poor weed control was obtained and consequently the yield was only about one-half that of the check.

Trifluralin + diphenamid (Incorporated pre-plant) Excellent control of all weeds present, except ragweed, was maintained the entire season. Yield was not affected.

Trifluralin 4E 1 lb AI/A (Incorporated pre-plant) Weed control was excellent the entire season. Ragweed was not controlled. The yield was not significantly different from that of the checks.

Lay-by Trial

Pertinent data are presented in Table II. Due to droughty conditions, weed growth was limited after lay-by. Under these conditions of moisture deficiency, however, the value of weed control late in the season is emphasized. The data below illustrate the importance of weed control after cultivation becomes impractical.

Table II. The effects of herbicides applied to tomatoes 7 weeks after transplanting on yield and weed control.

Lay-by Treatment	Lbs AI/A	Weed Control 1/ 8/6	Weed Control 1/ 9/7	Ave. Yield 2/ Tons/Acre
Cult. Check		8.3	7.0	15.52 c
Amiben 10G	4.0	9.0	8.5	15.79 bc
Diphenamid 5G	4.0	9.8	9.8	17.40 abc
R 2061 10G	6.0	10.0	8.5	17.00 abc
R 1607 10G	6.0	10.0	8.5	18.81 a
R 4461 10G	16.0	9.0	7.5	17.78 ab

1/ Rated 0 to 10 (10 represents nearly perfect control). Data are means of 4 replications.

2/ Means followed by the same letter are not significantly different at the 5% level. Coefficient of Variation-7.3%

Amiben Amiben provided some weed control, as shown in the ratings, but did not affect yeild.

Diphenamid Good control was obtained but the yield was not significantly improved over that of the check. The difference between the two means closely approached significance, however.

R 2061 Excellent control was obtained for about 5 weeks. The yield was not significantly increased.

R 1607 This herbicide gave excellent control for about 5 weeks and improved yields significantly.

R 4461 This treatment resulted in a yield greater than the check.

Summary

Trifluralin and trifluralin + diphenamid pre-plant incorporated gave excellent weed control (except for ragweed) the entire season without cultivation. There was no visible injury and no reduction in yield by these two pre-planting treatments. Harmful effects of cultivation were apparently balanced by beneficial effects as indicated by hand weeding treatments. R 1607 and R 4461 applied at lay-by resulted in significant yield increases. None of the treatments caused visible injury when applied at lay-by.

Literature Cited

1. 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.

CHEMICAL WEED CONTROL IN TRANSPLANTED TOMATOES

O. E. Schubert, R. F. Sweitzer, C. E. Hickman and C. B. Sperow[1]

Most of our tomatoes are grown on relatively heavy soils. Inasmuch as tomato production along river valleys has been increasing in West Virginia, this experiment was conducted on two widely divergent soils--a heavy clay at Morgantown and a very light sandy soil at the Ohio Valley Experiment Station at Point Pleasant. Similar herbicide treatments were evaluated at each location.

METHODS AND MATERIALS

The Heinz 1370 tomato seed for both sites was sown into flats at the University Greenhouse and then pricked-off directly into steam-sterilized soil in coldframes. Flats were not used in the coldframe since these plants, when later pulled prior to transplanting into the field, would more nearly resemble the "pulled" plants commonly used in commercial tomato plantings.

Morgantown Plots: The plants were set into the field on June 18 and 19, 1964. The treatments listed in Table 1 were assigned at random in each of the five replications. Eight herbicide treatments (2,3,4,5,6,7,8 and 10) were applied June 18 and 19. Treatment 11 (paraquat plus solan) was applied June 25 when the grassy weeds were about 2-3" tall. The plots in Treatment 12 were hoed until the lay-by application of DCPA plus diphenamid on July 24.

Point Pleasant Plots: The plants were set on June 12 and treatments 2,3, 4,5,6,7,8 and 10 were applied the same day. Treatment 11 (paraquat plus solan) was applied July 14 when the grassy weeds were about 2-3" tall. The plots in Treatment 12 were hoed until the lay-by application of DCPA plus diphenamid on July 29. These treatments at Point Pleasant differ from those at Morgantown in that a lower rate per acre of trifluralin plus diphenamid was applied in Treatment 2 and no hoed-check was included. The treatments were replicated only four times at Point Pleasant.

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.

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Table 1. Tomato herbicide treatments, weed control and yield at Morgantown.

No.	Treatment Herbicide-formulation (time, type application)	Rate ai lb/A	Weed Control 10=none 100=all Aug.12	Sept.30	Yield pounds per plot[f]	Yield pounds per acre
1	Check---Hoed as needed until August 10	----	93 ab	86 a	54.2 ab	16,396
12	DCPA[a] 3 G + Diphenamid 1 G (lay-by, surface)	6 + 2	99 a	95 a	61.4 a	18,574
7	Diphenamid 80 wp (pre-plant, soil incorporated)	6	87 ab	89 a	38.9 ac	11,767
8	Diphenamid 80 wp (post-plant, surface)	6	72 cd	75 a	34.0 ad	10,285
2	Trifluralin[b] 10 wp + Diphenamid 40 wp (pre-plant, soil incorporated)	0.75 + 3	83 bc	81 a	31.1 ae	9,408
11	Paraquat 2 ec + Solan 4 ec (post-plant, topical when grasses 2-3" tall)	0.1 + 4	84 bc	73 a	30.4 be	9,196
6	CP 31393[c] 65 wp (pre-plant, surface)	4	64 de	53 bc	31.6 ae	9,559
10	UC 22463[d] 5 G (post-plant, crop foliage dry)	8	32 f	33 ce	17.0 ce	5,142
4	G 14260[e] 50 wp (pre-plant, surface)	4	49 e	42 cd	16.6 ce	5,022
5	G 17269[e] 50 wp (pre-plant, surface)	4	17 gh	19 de	7.1 de	2,148
3	Prometryne 80 wp	4	57 e	35 cd	2.5 e	756
9	Check--non-hoed	---	10 h	10 e	9.3 ce	2,813

[a] A granular formulation of DCPA and diphenamid from the Miller Chemical and Fertilizer Corporation.
[b] Formulation of trifluralin and diphenamid called "Trefmid" from Eli Lilly and Company.
[c] From Monsanto Chemical Company
[d] From Union Carbide Chemicals Company
[e] From Geigy Agricultural Chemicals
[f] Plot size 8' x 18'. Plants set 2 feet apart in rows 4 feet apart.

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.

Table 2. Tomato herbicide treatments, weed control and yield at Point Pleasant.

No.	Treatment Herbicide--formulation (time, type application)	Rate ai lb/A	Weed Control 10=none 100=complete August 19	Yield in pounds per plot	Yield in pounds per acre
12	DCPA[a] 3 G + Diphenamid 1 G (lay-by, surface)	6 + 2	85 a	90 ab	24,210
7	Diphenamid 80 wp (pre-plant, soil incorporated)	6	40 de	75 ab	20,175
8	Diphenamid 80 wp (post-plant, surface)	6	60 bc	101 ab	27,169
2	Trifluralin[b] 10 wp + Diphenamid 40 wp (pre-plant, soil incorporated)	0.5 + 2	45 ce	101 ab	27,169
11	Paraquat 2 ec + Solan 4 ec (post-plant, topical when grasses 2-3" tall)	0.1 + 4	30 ef	83 ab	22,327
6	CP 31393[c] 65 wp (pre-plant, surface)	4	55 bd	104 ab	27,976
10	UC 22463[d] 5 G (post-plant, crop foliage dry)	8	65 b	116 a	31,204
4	G 14260[e] 50 wp (pre-plant, surface)	4	40 de	60 b	16,140
5	G 17269[e] 50 wp (pre-plant, surface)	4	20 fg	69 ab	18,561
3	Prometryne 80 wp	4	100 a	48 c	1,076
9	Check--non-hoed	----	10 g	66 ab	17,754

[a] A granular formulation of DCPA and diphenamid from the Miller Chemical and Fertilizer Corporation

[b] Formulation of trifluralin and diphenamid called "Trefmid" from Eli Lilly and Company

[c] From Monsanto Chemical Company

[d] From Union Carbide Chemicals Company

[e] From Geigy Agricultural Chemicals

[f] Plot size 6' x 27'. Plants set 2 feet apart in rows 3 feet apart.

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.

Morgantown Plots

Weed Control: Five herbicide treatments (12-DCPA plus diphenamid at lay-by; 7-diphenamid, soil incorporated; 2-trifluralin plus diphenamid, soil incorporated; 11-paraquat plus solan, applied when grassy weeds were 2-3" tall; and 8-diphenamid post-plant treatment on surface) were considered acceptable at evaluations made August 12 and September 30 (Table 1). Under the conditions of this experiment, diphenamid was more effective when incorporated than when applied to the soil surface. It should be noted that the observational weed control period for DCPA plus diphenamid was 7 weeks whereas all other treatments were rated for a 12-week period. In addition DCPA plus diphenamid was hoed until lay-by.

In the diphenamid plots control of grasses was nearly complete but common ragweed was not controlled satisfactorily, especially when diphenamid was applied on the surface. Paraquat plus solan controlled broad-leaved weeds but goosegrass and barnyardgrass were growing vigorously at the end of the season. The combination of trifluralin plus diphenamid did not completely control the ragweed and barnyardgrass. The combination of DCPA plus diphenamid gave early control of grasses and broad-leaved weeds. A few grasses were becoming established late in the season. The apparent better control with DCPA plus diphenamid may be accounted for in part by the extra five weeks of cultivation with only seven weeks remaining for chemical control.

In the remaining treatments there were limited numbers of broad-leaved weeds, mostly ragweed, and large quantities of goosegrass and barnyardgrass. Moderate numbers of yellow foxtail were also present in Treatments 3,4 and 5 (prometryne, G 14260 and G 17269, respectively). Small numbers of nutsedge were found in most of the herbicide plots.

Yield of Marketable Fruit: Yields at Morgantown fit into three numerical groups (high for DCPA plus diphenamid and hoed check; medium for diphenamid alone and with trifluralin, CP 31393, and paraquat plus solan; and low for UC 22463, G 14260, G 17269, prometryne and the non-hoed check). Statistically, DCPA plus diphenamid and the hoed check treatments had higher yields than treatments in the "low yield" group but were not higher than those of the "medium yield" group.

Plant Injury: Most of the plants in the prometryne plots were killed. Preliminary screening trials in the greenhouse indicated a higher crop tolerance than occurred in the field. Plants in Treatment G 14260 were smaller than unsprayed plants and had varying amounts of veinal chlorosis. Paraquat plus solan caused a temporary chlorosis of leaf margins with moderate to good recovery in a month. The other herbicide treatments did not cause any readily observable phytotoxic symptoms.

Point Pleasant Plots

Weed Control: The order or relative rank of treatments at Point Pleasant was similar to those at Morgantown with the following exceptions: one, prometryne controlled weeds the entire season but killed most of the tomato

plants; two, UC 22463 was promising although not commercially acceptable; and three, only early hoeing with DCPA plus diphenamid at lay-by gave good weed control. The possible reasons for differences and general lack of weed control at Point Pleasant may be the light sandy soil, general lack of rainfall (only 1.78, 1.98, 2.67, 4.38, and 3.38 inches in May, June, July, August and September), and abundance of common morningglory in all plots. A lack of control of ragweed also was observed at Point Pleasant. Yellow foxtail was found in all plots except those treated with prometryne, CP 31393 and UC 22463. Lambsquarters were found in smaller numbers in Treatments 5,6,8,10 and 12.

Yield of Marketable Tomatoes: Treatment 10 (UC 22463) produced significantly more tomatoes than Treatments 3 and 4. Other differences were not statistically significant, probably because of considerable variation between replications of the same treatment and too few replications.

SUMMARY

Three pre-plant or post-plant herbicide treatments (diphenamid, 6 lb/A ai, pre-plant, soil incorporated; diphenamid 6 lb/A ai, topical, post-plant; and trifluralin plus diphenamid, 0.75 + 3.0 lb/A ai, pre-plant, soil incorporated) gave satisfactory seasonal control of weeds from day of setting to end of harvest for Heinz 1370 tomatoes at Morgantown. Hoeing followed by a lay-by application of DCPA plus diphenamid in a granular formulation (6 + 2 lb/A ai) gave good weed control at both locations (Morgantown and Point Pleasant). An application of paraquat plus solan (0.1 + 4.0 lb/A ai) at the time grassy weeds were 2-3" tall gave satisfactory weed control at Morgantown but not at Point Pleasant.

Yields of marketable tomatoes from the diphenamid treatments, alone and with DCPA or trifluralin, and UC 22463 (8 lb/A ai) were not significantly less than the hoed check at Morgantown. The foregoing treatments and CP 31393 (4 lb/A ai) appeared promising at Point Pleasant but did not yield significantly more marketable tomatoes than the non-hoed check at that location.

ACKNOWLEDGEMENTS

The cooperation of the following companies in supplying the herbicides used in this experiment is gratefully acknowledged: California Chemical Company, Eli Lilly and Company, Geigy Agricultural Chemicals, Miller Chemical and Fertilizer Corporation, Monsanto Chemical Company, Niagara Chemical Division of Food Machinery and Chemical Corporation and Union Carbide Chemicals Company.

CONTROL OF BROADLEAF WEEDS IN SWEET CORN WITH PRE-EMERGENCE TREATMENTS

M.F. Trevett and William Gardner[1/]

Introduction

This paper is a report of the effectiveness of the herbicides listed in Table 1 on the control of annual broadleaf weeds in sweet corn.

Procedure

Carmel Cross sweet corn was planted in a loam soil 16 June, 1964.

Herbicides were applied pre-emergence on 22 June, 1964 with one pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. Treatments were replicated eight times.

The principal weeds included: Wild rutabaga (*Brassica rapa* L.), Red-root pigweed (*Amaranthus retroflexus* L.), and Lambsquarters pigweed (*Chenopodium album* L.).

Results

Stand of corn:

Four and six pounds per acre of NIA-7251 significantly reduced stand compared to all other treatments, Table 2.

The following:

one and two pounds of Atrazine
one pound of Atrazine plus either one pound Prometryne or one pound Ametryne
two pounds Ametryne
two and four pounds NIA-7251

gave significantly better broadleaf weed control than

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one pound 2,4-D with or without EPTC
one pound Prometryne
one, two, or three pounds of B-377

but statistically gave the same percent control as:

two pounds Prometryne
one pound Prometryne plus one pound Ametryne
one pound Ametryne, Table 3.

Yields:

Yields of snapped ears from plots treated with one pound of Atrazine per acre were not statistically surpassed by any other treatment, Table 4. Treatments not statistically different from one pound Atrazine were:

hand hoed
one pound Atrazine and of either Prometryne or Ametryne
one pound 2,4-D with or without 2 pounds EPTC
one or two pounds Prometryne
one or two pounds Ametryne
one pound Prometryne plus one pound Ametryne
two pounds Atrazine
one pound B-377

Conclusions

Where annual broadleaf weeds are the weed problem in sweet corn, one pound of Atrazine per acre is a satisfactory treatment from both the standpoint of weed control and yield. In the current test, the one pound rate of Ametryne did not differ significantly in effect from one pound of Atrazine.

Neither one pound of 2,4-D nor one pound of Prometryne differed significantly from one pound of Atrazine on yield, but they gave significantly poorer weed control.

Table 1. Herbicides Used in Sweet Corn Tests.

Designation	Active Ingredient
AMETRYNE	2-ethylamino-4-isopropylamino-6-methylmercapto-s-triazine
ATRAZINE	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
B-377	2,4-dinitrophenyl-(2'-sec-butyl-4',6'-dinitrophenyl) carbonate
EPTC	Ethyl N,N-Di-n-propylthiolcarbamate
NIA-7251	A Niagara Product
PROMETRYNE	2,4-bis(isopropylamino)-6-methylmercapto-s-triazine
2,4-D	2,4-dichlorophenoxyacetic acid

Table 2. Stand of Sweet Corn Per 25 Feet of Row.

Treatment number and acre rate of active ingredient	Number of corn plants per 25' of row
12. 1# B-377	34.9a[1/]
3. 1# 2,4-D + 2# EPTC	33.6ab
9. 1# Atrazine + 1# Prometryne	33.6ab
6. 1# Ametryne	33.5ab
1. Hand hoed	33.1ab
5. 1# Atrazine	32.9ab
7. 2# Ametryne	32.8ab
10. 2# Prometryne	32.4ab
13. 2# B-377	32.4ab
11. 1# Prometryne + 1# Ametryne	32.4ab
4. 1# Atrazine + 1# Ametryne	31.5ab
8. 1# Prometryne	31.4ab
2. 2# Atrazine	31.1ab
18. 1# 2,4-D	31.1ab
15. 2# NIA-7251	30.6ab
14. 3# B-377	30.0 b
16. 4# NIA-7251	18.9 c
17. 6# NIA-7251	8.0 d
L.S.D. 5%	3.8

1/ Duncan's Multiple Range Test.

Table 3. Percent Broadleaf Weed Control in Sweet Corn Following Pre-Emergence Treatments.

Treatment number and acre rate of active ingredient	Means: 3 August '64
1. Hand hoed	100.0a[1]
2. 2# Atrazine	100.0a
9. 1# Atrazine + 1# Prometryne	100.0a
15. 2# NIA-7251	100.0a
16. 4# NIA-7251	100.0a
4. 1# Atrazine + 1# Ametryne	99.4a
5. 1# Atrazine	98.2a
7. 2# Ametryne	95.6a
10. 2# Prometryne	93.9ab
11. 1# Prometryne + 1# Ametryne	92.8ab
6. 1# Ametryne	88.5ab
18. 1# 2,4-D	78.9 b
8. 1# Prometryne	77.5 b
14. 3# B-377	55.6 c
3. 1# 2,4-D + 2# EPTC	53.2 c
13. 2# B-377	43.4 cd
12. 1# B-377	33.8 d
20. Check	3.8 e
19. Check	3.0 e
L.S.D. 5%	13.7

1/ Duncan's Multiple Range Test.

Table 4. Yield of Sweet Corn Per 25 Feet of Row.

Treatment number and acre rate of active ingredient		Pounds of snapped ears per 25' of row
1.	Hand hoed	32.54a[1/]
9.	1# Atrazine + 1# Prometryne	32.3a
5.	1# Atrazine	32.0ab
4.	1# Atrazine + 1# Ametryne	30.9abc
18.	1# 2,4-D	28.3abc
10.	2# Prometryne	27.5abc
3.	1# 2,4-D + 2# EPTC	26.4abc
7.	2# Ametryne	26.4abc
11.	1# Prometryne + 1# Ametryne	25.9abc
6.	1# Ametryne	25.8abc
8.	1# Prometryne	25.7abc
2.	2# Atrazine	25.2abc
12.	1# B-377	24.8abc
13.	2# B-377	23.2 bcd
14.	3# B-377	22.8 cd
19.	Check	16.4 de
15.	2# NIA-7251	12.3 e
	L.S.D. 5%	7.3

1/ Duncan's Multiple Range Test.

The Effectiveness of Several Herbicides on Weed Control in Twelve Variety Sweet Corn Planting

By C. A. Langer[1] and Conrad Marcotte[2]

Introduction

It has not been possible to control late germinating broadleaf weeds and grasses in sweet corn consistently with one application of an herbicide. Injury will occur in some varieties some years. The efficiency in applying weed control chemicals in a single application at time of planting, or soon after, is a definite need in vegetable growing. The purpose of this study was to evaluate several herbicides for effectiveness in controlling broadleaf weeds and grasses, when applied at planting time under ample moisture controlled conditions. Also, symptoms of phytotoxicity appearing on any of the twelve varieties of sweet corn were to be observed in the test plots.

Procedure

A half acre of loamy sand soil was plowed, disked, dragged and marked and divided up into fifty plots of 1/100th acre per plot. The following herbicides and concentrations were tested: Linuron at 1 and 2 lbs; Atrazine at 2, 3, and 4 lbs; Simazine at 2 and 3 lbs; H95-1 at 2 and 3 lbs; Enide 5g at 4 and 5 lbs; and Enide WP at 4 and 5 lbs. Of the remaining 11 plots, 5 were cultivated and hoed twice and 6 were left as uncultivated checks.

All herbicide treatments were randomized in three replications. The twelve varieties of corn were then planted in rows 30 inches wide with three stalks in each 30 inches of row. Planting was done by hand on May 28th. If more than three stalks per 30 inches were present after stalks were 6 inches high, the excess plants were removed. The corn varieties were planted in a direction that assured treatment with most herbicides.

Plots were sprayed the day following the planting. Each 1/100th acre plot was covered uniformly with one gallon of spray or with the required amount of granules. Materials for each plot were carefully weighed out and placed in containers. The wettable powders were mixed at the plot with a measured gallon of water. A continuous pressure knapsack sprayer was used. This sprayer also was equipped with an agitator attachment to keep the wettable powder well dispersed in the water. Before application, the sprayer and applicator were tested for uniform application. After several trial runs with pure water, each of the applicators could apply one gallon to 1/100th of an acre with uniform skill. Soil was moist at planting time and .8 of an inch of rain was received 8 days after herbicides were applied.

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Because of drought conditions, it was necessary to irrigate the corn twice during the month of June. Ample rain was received in July and early August to mature an excellent sweet corn crop. No additional treatment was given to any of the treated plots after the original herbicide application.

Table 1. The Effectiveness of Several Herbicides on Weed Control in Sweet Corn.

No.	Treatment and Formulation	Rate (1) lbs/acre	Weed Control* 6/18	7/9	7/30	8/13	11/5
1	Linuron WP	1	10	9.0	8.5	8	7.5
2	Linuron WP	2	10	9.5	9.5	9.5	9
3	Atrazine WP	2	10	9.0	7.5	7.5	6.5
4	Atrazine WP	3	10	9.5	9.0	8.5	6
5	Atrazine WP	4	10	9.5	9.5	9	7.5
6	Simazine WP	2	10	10	9.5	8	7
7	Simazine WP	3	10	10	10	9.5	9
8	H95-1(3) WP	2	8	2	0	0	0
9	H95-1 WP	3	8	5	2	1	0
10	Enide 50 WP	4	10	8	6	4	0
11	Enide 50 WP	5	10	9	7.5	6	2
12	Enide 5g	4	10	8	5.5	2	0
13	Enide 5g	5	10	9	7.0	6	3
14	Cultivated ck.		9(2)	7.5	7.5	3	
15	Non-cultivated ck.		7	0	0	0	

* 0 = No weed control; 10= near perfect; 7.5 = commercial weed control
(1) Amounts are actual chemical per/acre
(2) Cultivated check plots were cultivated one day before weed counts were made
(3) H95-1 50% WP (Badische Anelin and Soda-Fabrik-Ag Ludwigshafen Am Rhein)

All plots were inspected for weeds and crop growth at weekly intervals. Accurate counts were made five times, four times during the season and one after harvest. The inspection after harvest was made after all corn stalks were removed from the field.

The principal weeds noted were: Smart weed (Polygonum pensylvanicum), Ragweed (Ambrosin artemisiifolia), Red Sorrell (Rumex acetosella), Purslane (Portulaca oleracea), Ivy Leaved Morning Glory (Lpomoea hederacea), Red Root Pig Weed (Amaranthus retroflexus), Lambsquarter (Chenopodium album L.), Crabgrass (Digitaria sanguenalis), Yellow Foxtail (Setaria lutescens), Blue Grass (Poa annua), Barnyard Grass (Echinochloa crusgalli), Knot Weed (Polygonum aviculare) and Gaint Foxtail (Setaria faberii).

Results and Discussion

It is evident from Table 1 that by July 9, H95-1 was not giving adequate control. By July 30, weeds and grass were growing as profusely as in the onon-cultivated checks. Enide 50 wettable powder at 5 lbs. and the granules at 5 lbs. held both the broadleaf weeds and grass in check up to 9 to 10 weeks from time of application. The 4 lb. rate in both wettable powder and granules failed to suppress weed growth more than 6 weeks. No significance in the quality or production of the sweet corn was noticed in any plots treated with 4 lb. Enide. The table 1 shows that excellent weed control was obtained with Linuron at 1 and 2 lbs. per acre. This was especially true with grass control. No damage to the corn was noted even with the highest concentration. Simazine controlled broadleaf weeds and grass at both 2 and 3 lbs. per acre without damage or ill effects to the crop. Atrazine at 2 lbs. gave satisfactory weed control, but 3 and 4 lbs. was much more effective in controlling grasses. Crabgrass was the weed that developed in the 2 lb. Atrazine plots. No ill effects were observed in stand, growth or production of any of the twelve varieties of sweet corn that made up the half acre planting. Although, all varieties were not exposed to each herbicide, the design of this test assured a test of a given chemical with at least six varieties. With excellent weed control and the lack of any toxic effects, the early Seneca 60 and 60II ripened for harvest 65 days from date of planting. Other varieties such as Senaca Carmelcross, Explorer and others all ripened within 3 to 7 days of that advertised as required for maturity. The cool summer in New Hampshire probably accounted for the delay in maturity for each variety.

Conclusions

The results this year show that several materials, such as Linuron, Atrazine and Simazine can be employed as a one-application herbicide at planting time. One can obtain the control needed for an excellent crop and production without danger of injury to the sweet corn. Another material, Enide, will give 6 to 8 weeks control. This can be applied after first or second cultivations and in this way, one application would hold through harvest.

The residue problem where sweet corn is rotated with other vegetables, such as beans, cabbage, cucumbers, etc. is most important. From experience, we know that problems have been encountered with some of these materials. It is hoped that a single application of these materials at planting time will reduce the residue by the following spring. Deep soil preparation perhaps will then eliminate any residue problems.

The use of chemical weed control makes it possible for one man to manage, grow and harvest many more acres of sweet corn than he could under the tractor cultivation methods.

CHEMICAL WEEDING OF ONION GROWN FROM SETS

Charles J. Noll[1]

Although the acreage of onions grown from sets in Pennsylvania is limited, the weeding of the crop with chemicals is of interest to a number of our market growers and most of our institutional managers. The experiment reported here is a continuation of the work started in 1963.

Procedure

The seedbed was prepared May 4. Tenoran was applied and incorporated May 5 and sets planted May 6. All pre-emergence treatments were applied either 1 or 5 days after planting and all post-emergence treatments 27 days after planting. Single row plots were 20 feet long and 2 feet wide. Treatments were randomized in each of 5 blocks. All chemicals except the incorporation treatment were applied in a 1 foot band over the row. The incorporation treatment was applied in a 2 foot band.

Cultivation controlled the weeds between the rows. An estimate of weed control was made June 24 on a basis of 1 to 10, 1 being most desirable and 10 least desirable. Onions were harvested September 6.

Results

The results are presented in Table I. Fifteen of eighteen treatments resulted in a significant increase in weed control as compared to the untreated check. No treatment resulted in a reduction of stand of onions and 11 of the 18 treatments resulted in a significant increase in yield as compared to the untreated check plot.

Conclusion

Under the condition of this experiment, the most promising chemicals for weeding of set onions are CP 31393 at 4 lbs. per acre applied 1 day after planting, CIPC at 8 lbs. per acre applied 1 day after planting and again 27 days after planting and DCPA at 16 lbs. per acre applied 1 day after planting and again 27 days after planting.

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Table I. 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 * Weed Control 1-10	Number of Bulbs	Weight of Bulbs lbs.
1 Nothing	--	--	9.8	81	4.4
2 Tenoran	6	Inc. - 1	8.6	99	6.0
3 CIPC (2 applications)	8 + 8	Pre + 1 & Post + 27	2.2	98	10.2
4 DCPA (2 applications)	16 + 16	Pre + 1 & Post + 27	2.4	81	8.2
5 KOCN (2 applications)	16 + 16	Pre + 5 & Post + 27	7.2	91	6.5
6 Bayer 58119	5	Pre-e + 1	6.4	80	5.9
7 TD 480	10	" + 1	2.8	93	8.1
8 CP 31393	4	" + 1	1.0	95	9.6
9 TH 052-H	4	" + 1	4.6	99	8.4
10 TH 052-H	8	" + 1	6.6	93	7.6
11 Casoran	4	" + 5	5.6	80	5.9
12 Alipur O + DNBP	1 + 1	Pre-e + 5	5.6	99	7.4
13 Pyrazon	4	" + 5	6.6	101	7.3
14 Pyrazon + TOK	2 + 2	" + 5	5.4	101	7.6
15 Pyrazon + CIPC	2 + 2	" + 5	8.0	89	6.2
16 Pyrazon + CIPC	4 + 4	" + 5	5.4	97	8.1
17 Pyrazon + ACP 63-303	4 + 3/4	Pre + 4 & Post + 27	4.6	99	8.4
18 Amiben + ACP 63-303	6 + 3/4	Pre + 1 & Post + 27	1.0	80	4.8
19 ACP 63-303	3/4	Post + 27	6.4	90	6.1
Least significant difference	5%		2.8	16	2.5
Least significant difference	1%		3.7	NSD	3.3

*Weed Control 1-10: 1 perfect weed control
10 full weed growth

GROWING OF SMALL SEEDED VEGETABLES WITHOUT CULTIVATION

Charles J. Noll[1]

The present day practice of growing crops in rows was developed primarily around the need for cultivation. The major value of the cultivation was for weed control. With the introduction of good herbicides, fundamental changes in crop production practices are occurring. Where herbicides are used reduction in the amount of tillage needed to grow a crop has already taken place. The value of any cultivation is now in question if all weeds can be eliminated by using an herbicide.

A number of herbicides used in the weeding of carrots and parsley have in the past years given seasonal control of weeds in the row. This year an attempt was made to grow these crops in closely spaced rows and weed with an herbicide. It was expected that close spacing of the rows would result in increased yields as compared to wider spaced rows that received cultivation if weeds were not a problem.

Procedure

These trials were conducted at The Pennsylvania State University Horticultural Farm 10 miles west of University Park. The soil is a Hagerstown silt loam. The season was dry but no irrigation was applied. On May 11, the seedbed was prepared and soil incorporation treatments applied and incorporated with a rototiller set shallow. The plots were seeded the next day with the carrot variety, Chantenay Red Cored and the parsley variety, Perfection. All plots were 18 feet long. The single row cultivated plots were 2 feet apart. The uncultivated plots were 3 rows each with 6 inches between rows. Pre-emergence treatments were applied 1 day after seeding and the post-emergence treatment 29 days after seeding. Treatments were randomized, carrots in each of 8 blocks and parsley in each of 4 blocks.

All chemicals were applied with a small sprayer for a width of 2 feet. This included the guard rows. Scattered weeds were removed by hand early in the season. Carrots and parsley in rows 2 feet apart were cultivated 3 times. Carrots were harvested September 14 and parsley September 11.

Results

The results are presented in Tables I and II. Weeds were not a problem. With all chemicals, yields were higher in uncultivated plots with 6 inches between rows as compared to cultivated plots with 2 feet between rows on an equal area basis. Based on total weight of roots, the two best carrot treatments in the uncultivated plots were CIPC, Stoddard Solvent combination and amiben. The best three treatments in the cultivated plots were DCPA, CIPC, Stoddard Solvent combination and trifluralin. In the parsley plots one treatment, amiben, was significantly poorer than the other 4 treatments: DCPA, prometryne, trifluralin and the combination treatment of CIPC and Stoddard Solvent.

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Conclusion

Under the conditions of this experiment parsley and carrot grown in rows 6 inches apart and weeded with an herbicide outyielded the same crops grown in rows 24 inches apart weeded with an herbicide and cultivated. The complete elimination of all cultivation may now be possible with a number of vegetable crops if weeded with an herbicide.

If after more thorough investigation it is found that cultivation can be eliminated where herbicides control all the weeds the next logical step is to eliminate row plantings. Plants equal distant from all neighboring plants would be expected to outyield plants grown in rows.

Table I. Number of plants and weight of roots of carrots from cultivated and uncultivated plots under chemical herbicide treatments

Treatment	Active Rate per Acre, lbs.	Application Days from Planting	Average per Plot (equal area basis) Number of Plants 6" rows Not Cultivated	Number of Plants 24" rows Cultivated	Weight of Roots, lbs. 6" rows Not Cultivated	Weight of Roots, lbs. 24" rows Cultivated
trifluralin	3	Inc. - 1	334	58	21.1	14.0
DCPA	24	Pre-emerg. + 1	328	73	21.2	17.2
prometryne	4	" + 1	182	26	18.0	8.3
amiben	12	" + 1	305	38	25.8	12.0
CIPC + Stoddard S.	6 + 70 gal.	Pre. +1, Post + 29	738	65	27.0	15.1
Least significant difference 5%			87	22	4.3	4.9
Least significant difference 1%			118	30	5.7	6.6

Table II. Weight of leaves of parsley from cultivated and uncultivated plots under chemical herbicide treatment

Treatment	Active Rate per Acre, lbs.	Application Days from Planting	Average per Plot (equal area basis) Weight of leaves lbs. Row 6" Apart Not Cultivated	Row 24" Apart Cultivated
trifluralin	3	Inc. - 1	6.6	4.5
DCPA	24	Pre-emerg. + 1	7.7	3.7
prometryne	4	" + 1	6.8	3.4
amiben	12	" + 1	3.6	0.6
CIPC + Stoddard S.	6 + 70 gal.	Pre + 1, Post + 29	6.5	2.8
Least significant difference 5%			1.0	1.7
Least significant difference 1%			1.5	2.3

Chemical Weed Control in Sweet Potatoes[1/]

J. D. Long and W. A. Matthews[2/]

Maryland produces some 4000 acres of sweet potatoes each year, most of which are grown on the Eastern Shore. Sweet potato growers must cultivate frequently (4-8 times per season) and hand hoe once or more to produce a weed free crop. The frequent cultivations are required in part to keep the vines trained down the rows to allow for later cultivations. Normally by 8-10 weeks after planting there is sufficient vine growth to shade the ground and prevent further weed infestation.

Herbicides can be used to eliminate some, if not all, cultivations and hoeings required in sweet potato production. Under present fertilization practices, yields are usually improved if the crop is sidedressed at least once. Herbicides must then be either unaffected by tillage or their application must be delayed until after the sidedressing. Reliability of herbicides used early in the season is extremely important if no cultivation is to follow. Consistent, nearly perfect weed control lasting until the vines completely shade the ground is necessary because vine growth soon prevents cultivation. Herbicides also might be useful for application at an early lay-by (last cultivation). This could eliminate 1 or 2 cultivations as well as prevent late-season weed growth.

Materials and Methods

Twelve herbicides or their combinations were evaluated for use on sweet potatoes during the 1964 growing season. The trial was conducted on a sandy loam low in organic matter at the University of Maryland Vegetable Research Farm at Salisbury. Predominant weeds were crabgrass, goosegrass, lovegrass, lambsquarter and pigweed. Ragweed and morning glory were present to a lesser extent.

The early part of the season was dry. A one-fourth inch rain on May 13 was the only appreciable moisture received that month. The total rainfall for May was only 0.40 inches. On June 2 a one-half inch rain was received. This was followed by two more weeks of dry weather. The last half of June and all of July had sufficient rainfall. August was again dry with a total of only 0.62 inches of rainfall in 8 light showers. No irrigation was applied.

Herbicides were broadcast over the entire plot area with a tractor-mounted boom sprayer at 50 gpa or a fluted-roller granular distributor (1) set for a constant rate. All herbicides were applied to dry soil. Pre-planting treatments were applied May 21 and incorporated (within 15 minutes) 3-4 inches using a Tilrovator[3/].

1/ Scientific Article No. A1164, Contribution No. 3637 of the Maryland Experiment Station, Department of Horticulture.

2/ Research Assistant and Associate Professor, University of Maryland Vegetable Research Farm, Salisbury, Maryland.

3/ Tilrovator manufactured by Ferguson Manufacturing Co., Suffolk, Virginia.

Nemagold sweet potato sprouts were transplanted May 22. Treatments were arranged in randomized complete blocks with 4 replications. A single plot consisted of 3 rows 30 feet long and 36 inches apart. Plants were spaced 12 inches apart in the row. Only the center row was used for records.

Five post-planting treatments were applied the day of transplanting. Two lay-by treatments were applied July 1. The lay-by plots were cultivated (6/4, 6/17, 6/29) and hoed (6/18, 7/1) on the same dates as the cultivated check plots. One lay-by treatment (amiben) was cultivated lightly after application to incorporate the herbicide. Plots treated before and the day of planting were never cultivated. Another treatment (paraquat + trifluralin) was applied July 1 to plots that also received no cultivation during the season. Fertilizer applied after planting was banded on the soil surface. The sweet potatoes were harvested, graded and weighed September 17.

Results and Conclusions

Weed control, crop plant injury and yield data are presented in Table I.

CP 17029 2E (3 lb ai/A post-planting 5/22). Sweet potatoes were severely injured with the plant stand reduced by more than one-half. Weed control was very poor.

CP 31675 75W (3 lb ai/A post-planting 5/22). This material gave poor weed control. Injury was moderate and the yield was reduced below that of the cultivated check.

CP 17029 + CP 31675 (1.5 + 1.5 lb ai/A post-planting 5/22). The combination of these two herbicides caused considerable injury and gave poor weed control. Plant stand and yields were both greatly reduced.

Diphenamid 80W (4 lb ai/A post-planting 5/22). Diphenamid caused no visible injury but failed to give acceptable weed control. Yield was significantly reduced due to the weed competition. Grasses were almost completely controlled while broadleaf weeds, especially lambsquarter, were very poorly controlled.

H 7531 80W (4 lb ai/A lay-by 7/1). Nearly perfect weed control was maintained for the remainder of the season without injury to the crop. The yield was not affected.

Paraquat + trifluralin (0.5 + 1.0 lb ai/A 7/1). Most weeds were killed, but the crop was severely injured. The sweet potatoes recovered quickly, however. All weeds except goosegrass were controlled for the remainder of the season. Yield was much lower than the cultivated check yield.

R 1607 6E (6 lb ai/A incorporated pre-plant 5/21). Perfect weed control was maintained the entire season. The yield, however, was reduced due to herbicidal injury. The injury appeared primarily as stunting, although there may have been some reduction in plant stand (not statistically significant in this trial). Earlier application or slightly lower rates should result in less injury without sacrificing much weed control effectiveness.

R 4461 4E (12 lb ai/A post-planting 5/22). R 4461 caused no visible injury but gave poor weed control. Yield was reduced about one-half.

R 4572 6E (6 lb ai/A incorporated pre-plant 5/21). Weed control was excellent the entire season with no reduction in yield.

Trifluralin + diphenamid[1/] (2.5 lb ai/A incorporated pre-plant 5/21). Excellent weed control was maintained the entire season. Though not significantly less than the check, yield was lower than that of the amiben treatment. Slight stunting was apparent early in the season which may have accounted for the yield reduction.

Trifluralin 4E (1 lb ai/A incorporated pre-plant 5/21). Nearly perfect control of weeds was provided the entire season. Stunting was apparent early in the season, and the plant stand seemed to be reduced. Yield was not significantly different from the yield of the cultivated check treatment.

Summary

Herbicides applied to the soil surface soon after planting failed to give acceptable weed control under droughty conditions. Trifluralin, trifluralin + diphenamid, R 1607 and R 4572 incorporated the day before planting gave nearly perfect weed control the entire season without cultivation. R 4572 caused no reduction in yield while other pre-planting treatments reduced sweet potato production considerably. Amiben and R 7531 applied at the last cultivation maintained excellent weed control the remainder of the season without injury.

Literature Cited

1. Riggleman, J. D., G. J. Burkhardt and F. C. Stark, 1963. A gradient distributor for the application of granular materiels. Proc. Northeastern Weed Control Conference, p. 73.

1/ Trefmid 50W (10% trifluralin + 40% diphenamid).

Table I The effects of various herbicide treatments on weed control, injury and yield of sweet potatoes[1/].

Treatment	Lbs. AI/A	Application	Weed Control[2/] 6/19	8/4	9/15
Cultivated Check			10.0	7.3	7.0
CP 17029 2E	3	Post-plant	9.3	2.8	1.0
CP 31675 75W	3	"	9.8	6.5	5.3
CP 17029 + CP 31675	1.5+1.5	"	9.8	5.3	4.8
Diphenamid 80W	4	"	8.3	6.0	4.3
H 7531 80W	4	Lay-by	10.0	10.0	10.0
Paraquat 2E + trifluralin 4E	0.5+1.0	7/1	7.8	5.3	4.8
R 1607 6E	6	Pre-plant inc.	10.0	10.0	10.0
R 4461 4E	12	Post-plant	9.5	3.3	2.5
R 4572 6E	6	Pre-plant inc.	10.0	9.8	9.8
Trifluralin + diphenamid[3/]	2.5	" "	9.8	9.8	10.0
Trifluralin 4E	1.0	" "	10.0	9.8	9.8
Amiben 10G	4	Lay-by inc.	10.0	10.0	10.0

Treatment (as above)	Injury[4/] 6/19	8/4	9/15	Number of Plants[5/]	Bu/A[6/]
Cultivated Check	10.0	10.0	10.0	24.75 ab	222 abc
CP 17029	3.8	5.0	7.3	10.75 c	20 f
CP 31675	9.8	8.5	10.0	20.75 ab	139 d
CP 17029 + CP 31675	6.3	6.5	9.5	13.75 c	60 ef
Diphenamid	10.0	10.0	9.5	23.50 ab	145 d
H 7531	10.0	10.0	10.0	24.75 ab	220 abc
Paraquat + trifluralin	10.0	7.8	10.0	24.75 ab	125 de
R 1607	9.5	9.3	10.0	20.50 ab	172 cd
R 4461	10.0	10.0	10.0	22.75 ab	113 de
R 4572	9.8	10.0	10.0	23.75 ab	252 ab
Trifluralin + diphenamid[3/]	9.5	10.0	10.0	23.75 ab	182 bcd
Trifluralin	8.5	9.3	10.0	19.50 b	126 de
Amiben	10.0	10.0	10.0	25.75 a	288 a

1/ Nemagold sweet potatoes planted 5/22, harvested 9/17. Data are means of 4 replications.

2/ Rated 0-10 where 10 = nearly perfect control.

3/ Trefmid 50W (10% trifluralin + 40% diphenamid).

4/ Rated 0-10 where 10 = no apparent injury.

5/ Number present at end of season; 30-32 were planted in all plots.

6/ Total U.S. No. 1 & 2 grades; 50 lb = 1 bushel. Means followed by the same letter are not significantly different at the 5% level.

TD 480 AND RELATED MATERIALS AS HERBICIDES ON VEGETABLE CROPS

H. L. Lindaberry and F. E. Temby[1]

TD 480 is a highly water soluble inorganic pre emergence herbicide. The material is leached rapidly in sandy and high organic soils that contain little clay. In these cases where there has been adequate rainfall, weed control was poor and crop injury was frequently encountered. To date the weed and crop susceptibility to TD 480 is indicated as follows. The crops with an asterisk may be doubtful as to susceptibility at 8 pounds per acre.

CROP

Resistant	Intermediate	Susceptible
Onions	Radish	Wheat
Safflower	Tomatoes	Corn
Oats	Cabbage	Soybean
Alfalfa*	Beets	Snapbean
Flax	Cotton	Limabean
	Peanuts	Peas
	Sorghum	Red Clover
	Squash	
	Turnips	
	Lettuce	

WEEDS

Resistant	Intermediate	Susceptible
Velvetleaf	Mustard*	Pigweed
	Smartweed	Lambsquarter
	Barnyard grass	Crabgrass
	Wild Oats*	Foxtail
		Quackgrass

TD 1015 is a water insoluble derivative of TD 480. In tests to date it seems equally effective on sand and clays and also gives better selectivity on certain crops, due to placement tolerance. It is expected that the crops listed as intermediate in tolerance to TD 480 may be treated with TD 1015, especially the crops seeded at least one inch in depth. Corn has also shown tolerance to TD 1015. There are indications also that the dosages may be reduced from the 8 pounds suggested for TD 480. Trials at 2 and 4 pounds per acre are suggested.

In Canada on tomatoes TD 480 at 12, 9, and 6 pounds per acre gave 77, 53, and 37 percent weed control after 3 months as compared with 43% for 4 pounds

1. Technical Supervisor and Assistant Technical Supervisor, respectively, Pennsalt Chemicals, Aurora, Illinois.

amiben granular, and 50 percent for diphenamid at 4 pounds. Rates above 9 pounds reduced yields significantly and foliage injury was noted at 9 and 6 pounds.

In Pennsylvania on onions, TD 480 at 10 pounds per acre gave 72 percent weed control with a yield of 8.1 pounds per plot as compared with 4.4 pounds for the check.

On sweet corn 10 pounds of TD 480 gave 85 percent weed control but reduced the yield by 50 percent.

On direct seeded tomatoes at 8 and 12 pounds TD 480 gave 89 and 87 percent weed control with the yields reduced slightly over the check.

On tomato transplants TD 480 at 8 and 12 pounds gave 81 and 85 percent weed control respectively, with total yields comparable to the check, however; the first picking yields were reduced.

In New Jersey on corn TD 480 at 8 and 10 pounds gave 67 and 74 percent control of broadleaves and 78 and 78 percent control of grasses respectively. Atrazine 80W at 1½ pounds gave 61 percent control of broadleaves and 45 percent on grasses. There was no significant crop injury at either rate with TD 480.

In Iowa on onions TD 480 at 8, 12, and 16 pounds per acre reduced grasses 83, 77, and 100%; purslane 98, 99, and 100%; and pigweed 96, 96, and 100% respectively. Yields were comparable at all rates with CIPC at 4, 6, and 8 pounds per acre.

TD 480 was applied to direct seeded onions at rates of 2.25 - 15.0 pounds per acre at Delaware. Good annual grass and broadleaf weed control was obtained at 5.4 pounds per acre and above. There was no crop injury at 15 pounds per acre.

Summary

Since TD 1015 is more active on a wider range of soil types than TD 480, we will be testing TD 1015 exclusively in 1965.

TD 1015 liquid and granular samples will be available for testing on horticultural and agronomic crops this year. To reduce the possibility of injury, the granular TD 1015 should be used on transplant tomatoes and other transplanted crops.

Data to date indicate that additional trials at 4-8 pounds per acre should be conducted on onions and tomatoes as well as cabbage, lettuce, radish, beets, squash and turnips.

CONTROL OF ANNUAL WEEDS IN KATAHDIN POTATOES (URI 1964)[1]

R. S. Bell and S. Kenyon[2]

Introduction

Control of weeds in potato fields is complicated by a variety of annuals and perennials that thrive after the crop is hilled. After midseason potatoes are not cultivated because of their extensive growth. During this period the potato plants shade the soil and are highly competitive with weeds. By August the weight of the vines causes them to drop down against the soil and the lower leaves disappear due to shading during the period of rapid growth. This exposes the soil at the top of the potato hills and weeds begin to grow. As the vines mature, the soil between the rows is exposed. Here a new crop of annual weeds germinates and perennials gain in vigor as the potatoes become less competitive. The largest annual weeds are found on top of the hills.

The weed situation in Rhode Island potato fields

Perennial weeds found in Rhode Island potato fields are nutsedge, quackgrass, hedge bindweed and Jerusalem artichoke. Redrooted pigweed, lambsquarters, ladysthumb, wild radish, Pennsylvania smartweed, common ragweed, chickweed and field spurry are dicotyledonous annuals commonly found in potato fields. Among the annual grasses are the smooth and hairy crabgrasses, fall panicum, barnyardgrass and yellow foxtail.

Because of the narrow margin of profit and high cost of controlling insects and diseases, farmers hesitate to invest additional money in chemical weed control. Bell and co-workers (1) have shown that EPTC may be used to control nutsedge in potatoes but costs $16 to $20 per acre. The use of DNBP at preemergence plus one or two cultivations, followed by hilling, may give adequate weed control until August 15. From then until killing frost, weed growth may be extensive. By this time there is a considerable yield of tubers in the soil so that competition from the weeds does not prevent a fair harvest. The harvest time in Rhode Island starts by August 1 and extends into November.

Detrimental effects of weeds

A rampant growth of weeds interferes with the control of insects, diseases and the use of the vine killing spray to harden the potatoes before harvest. Weeds do not impede the operation of the large potato digger combines as much as did the smaller, old-fashioned type. A thick stand of nutsedge or quackgrass tends to bind the tubers into a ribbon of sod so that some pass over the digger chain along with these weeds.

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[2]Associate Professor and Graduate Assistant, respectively, Department of

Why cultivatate and hill potatoes?

Whether cultivation of potato is necessary is a subject of academic debate. Bell and Regan (2) reported that during 1962 and 1963 an excellent crop of Kennebec potatoes was grown without any mechanical cultivation where 2 to 4 lbs/A of Linuron were used preemergence. They noted, however, as did Bell and Tisdell (5), during the dry year 1957, that potato plants had a better color and withstood drought better when cultivated.

Growers prefer to have their potatoes hilled. It is much easier to follow the rows with the digger, the drag on the tractor is less and smaller amounts of soil are carried over the digger chains.

Procedures

Experimental conditions

In this test various herbicides were applied before planting, after planting but before emergence of potatoes, and at layby immediately after hilling.

The area was Bridgehampton silt loam soil on which forage grasses were grown for several years. Although the sod was plowed under and disked in October 1963 several of the perennial grasses (quackgrass, smooth bromegrass, reed canarygrass and orchardgrass, timothy, tall fescue and nutsedge) persisted. Records showed that a heavy infestation with annual weeds was present when the area was previously cropped to potatoes. The soil was not replowed in the spring of 1964 but was disked vigorously after a broadcast application of Cyanamid at 200 lb /A.

Katahdin potatoes were planted for all treatments on April 28 with a 9" spacing in the row and 3' between rows. All plots were 36' long and 2 rows wide with 4 replicates of each treatment. A complete 10-10-10-1.2 low chloride fertilizer was applied in bands as the tubers were planted.

Cultivation omitted on some treatments

Originally it was planned to cultivate the preplant and preemergence potatoes about the third week of June. By the time equipment was available, however, the potato plants had closed in across the rows so that cultivation was not feasible. A section on the south side was reserved for a layby application of granular Amiben. This area was clean cultivated three times and handhoed to inhibit the quackgrass.

The weather was unusually dry from April 15 to June 30. Total rainfall was as follows: April 15 to 30, 0.95"; May, 0.67"; June, 0.86" and July, 4.46". On June 3 about 3/4" of irrigation water was applied with rotating sprinklers.

Both potato and weed growth were excellent during July with the more adequate rainfall. On August 13 the area was sprayed with a light application of sodium arsenite vine killer to dry up the potato vines so a good estimate of annual grasses could be made.

Preplant Herbicide Tests

Eptam 6E and 10% granular, Vernam 6E and 10% granular, Treflan and Trefmid were applied on the first section of the area and thoroughly disked into the soil before planting. See Table 1 for rates and results.

Table 1. Effects of preplant herbicides on Katahdin potatoes (1964).

Material	Active toxicant lb/A	Ratings* of weed concentration: Annual grasses July 6	Annual grasses August 20	Annual dicots July 6	Annual dicots August 20	US #1 tubers cwt/A
Eptam 6E	4½	8.0	8.5	8.0	8.7	198
Eptam 5G	4½	9.7	9.7	9.7	9.7	188
Trefmid	2½	5.0	4.0	5.0	4.0	195
Trefmid	5	9.0	9.0	8.0	7.0	191
Treflan	1	7.5	4.0	8.0	5.0	179
Treflan	2	8.0	6.0	8.5	5.0	180
Vernam 6E	4½	8.7	8.5	8.0	7.0	177
Vernam 5G	4½	9.7	9.7	9.7	8.5	202
No treatment	-	6.0	3.0	5.0	5.0	173
						NS

* 1 = very heavy weed concentration, 10 = no weeds

Granular Eptam or Vernam disked into soil before planting at 4½ lbs/A gave complete annual weed control during the summer. Some late germinating crabgrass was starting in those plots which received the Eptam or Vernam emulsions. Trefmid at 5 lb /A controlled annual grasses but allowed considerable ragweed and ladysthumb to survive. Treflan at 1 or 2 lb /A afforded slight retardation of annual weeds.

The rather dry season of 1964 was ideal for control of annual weeds, both grasses and dicots, with Eptam and Vernam. The granular preparation was more effective than the spray.

Preemergence Herbicides

The preemergence treatments were applied May 14. Kinds and amounts of herbicides and results are presented in Table 2. Very light rain preceded and followed their application. The soil surface was mellow and moist at the time.

Table 2. Effects of preemergence herbicides on Katahdin potatoes (1964).

Material	Active toxicant lb/A	Rating of weed concentrations: Annual grasses July 6	Annual grasses Aug. 20	Annual dicots July 6	Annual dicots Aug. 20	US #1 tubers cwt/A	Duncan's significance*
Linuron	2	8.0	8.5	9.0	8.5	244	*
SD 9515	4	7.0	4.0	8.5	5.0	240	*
Cultivation	-	9.5	8.5	9.8	9.5	224	
Enide	5	6.5	7.5	6.5	5.5	218	*
DNBP	3	7.0	6.5	9.0	6.5	214	
DCPA	7.5	8.5	8.5	8.0	4.5	214	*
DNBP + Falone	1 gal	7.0	4.0	9.0	9.0	209	
SD 9515	8	3.5	6.5	9.0	6.5	209	
Linuron	3	9.0	9.0	9.0	9.0	209	
G-14260	1	3.0	4.0	8.0	5.0	208	*
UC 22463	4	6.5	6.5	8.0	5.5	205	*
G-14260	2	8.0	7.0	9.0	6.0	204	
Dymid	4.8	9.0	9.0	9.0	5.5	202	
Check	-	5.0	5.0	5.0	5.0	199	
Trefmid	2.5	9.0	9.0	6.5	4.0	198	
G-14260	4	7.0	5.0	8.5	5.0	196	
Eptam 6E	4.5	9.0	9.5	8.5	8.5	186	
UC 22463	8	7.0	3.0	9.0	7.0	184	*
Treflan	1	9.0	3.0	9.0	5.0	172	
Vernam 6E	4.5	9.0	8.0	6.0	6.0	170	*

*Range 19 Sign. value 35 Range 2 = Sign. value 29

The sprays were applied with a tractor-drawn sprayer at a rate of 50 gal/A. A weeder was hitched between the tractor and the sprayer so that the spray fell on freshly stirred soil. One pass of the weeder was used to stir the Eptam 6E and Vernam 6E into the surface soil directly after spraying. The checks also received one pass of the weeder. The soil was full of freshly germinated weed seeds at this time. Their growth was disrupted and some were undoubtedly killed as a result of the weeder action.

After killing back the potato vines in mid-August with sodium arsenite, the concentration of annual grasses and dicots were estimated on a scale of 1 to 10. One indicates a large weed population and 10 indicates the absence of weeds. Fall panicum (Panicum dichotomiflorum) was the most prevalent grass, followed by the crabgrasses. There was a spotty distribution of barnyardgrass. Ragweed (Ambrosia artemisiifolia) was the commonest annual dicot, while ladysthumb (Polygonum persicaria), lambsquarters and redrooted pigweed were encountered occasionally. The weed ratings for July 6 and August 20 and yields of potatoes are shown in Table 2.

Preemergence results

Linuron 50W at 2 or 3 lb /A was the most effective preemergence herbicide since it controlled most annual grasses and dicots.

Eptam 6E and Vernam 6E which were stirred in with one pass of the weeder were not as effective as the preplant applications which were disked into the soil. Eptam seemed more effective than Vernam which did not suppress the ragweed or ladysthumb. Eptam also seemed more effective than Vernam on annual grasses.

Dacthal at 7½ lb /A kept the annual grass population at a minimum but did not control ragweed or ladysthumb. Similar results were obtained with Enide, Dymid and Trefmid which produced good control of grasses and poor control of dicots. Treflan at one pound per acre was ineffective under the conditions of this test.

SD 9515 did not prevent germination of annual grasses but slowed their growth so that they were half as tall as the untreated ones (18" vs 9"). A normal stand of ragweed and ladysthumb developed where 4 lb /A rate of SD 9515 was used. The 8 lb /A rate was slightly more effective than the lower one.

According to Duncan's multiple range test, the yields of US #1 tubers from 15 of the 20 treatments did not vary significantly from each other. The uncultivated check ranked 14 (199 cwt/A) when the yields were listed in descending order but the cultivation check ranked third (224 cwt/A). The highest yield was 244 cwt/A where Linuron was used at 2 pounds.

No particular relationship is shown between the weed estimates and yields. It should be remembered that the potato vines were killed in mid-August at about the time late summer weeds gain dominance over late potatoes. The random distribution of perennial grasses in the plots may have contributed to the variability of yields.

Preemergence conclusions

Linuron, clean cultivation and Eptam 6E were effective in controlling both annual grasses and dicot weeds. Certain chemicals such as Dacthal, Dymid and Trefmid were effective in the control of annual grasses but allowed many dicots to persist.

Layby Test with Granular Amiben

The NE-36 committee, which is checking for pesticide residues, asked that granular Amiben (10% active) be applied to potatoes at layby. The potatoes were cultivated 3 times and hilled on June 26. They were also hoed twice to inhibit quackgrass.

The Amiben was used at the rate of 4 and 8 lb /A active ingredient shortly after hilling. The granules were mixed with coarse sand and the proper

amount distributed by hand on each plot. The report (4) on Amiben residue is included in this volume of proceedings.

The yields of US #1 tubers were 232, 225 and 224 cwt/A for the 4 lb/A, 8 lb/A and check, respectively. Considerable crabgrass was developing in the checks but was no threat to yields when the potatoes were dug in late August. The Amiben plots were nearly weedfree.

Summary

As in the 1962 and 1963 studies, a satisfactory crop of potatoes was grown by mid-August without cultivation where Linuron was applied preemergent to the potato crop. In 1964 granular Eptam or Vernam disked into the soil before planting gave almost complete control of both annual grasses and dicot weeds until digging time in late August. Cultivation and hilling is also a satisfactory method of weed control. Considerable development of weeds occurs after mid-August. Amiben following hilling retards the development of weeds in late summer and early fall.

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APPENDIX

Herbicides Used on Potatoes - 1964

Amiben (granular 10%	3-amino-2,5-dichlorobenzoic acid (Amchem)
DNBP (4 lb/gal)	4-6-dinitro-o-sec butylphenol (Dow)
DNBP + Falone (2,4-D EP)	4-6-dinitro-o-sec butylphenol + Tris(2-4-dichlorophenoxyethyl) phosphite (Naugatuck)
Dacthal (75W) (DCPA)	dimethyl ester tetrachloroterephthalic acid (Diamond Alkali)

Dymid (80W)	N,N-dimethyl-2,2-diphenylacetamide (Elanco)
Enide (50W)	N,N-dimethyl-2,2-diphenylacetamide (Upjohn)
Eptam 6E (6 lb/gal)	ethyl N-N-di-n propylthiocarbamate (Stauffer)
Linuron (50W)	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (DuPont)
Prometryne (50W)	2,4-bis(isopropylamino)-6-methylmercapto-s-triazine (Geigy)
Treflan (4 lb/gal)	a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (Elanco)
UC 22463 (80W)	3,4-dichlorobenzyl-N-methylcarbamate (Union Carbide)
Vernam 6E (6 lb/gal)	n-propyl-d-n-propylthiolcarbamate (Stauffer)

Compositions of G 14260 and SD 9515 were not disclosed.

BROADLEAF WEED CONTROL IN WHITE POTATOES WITH PRE-PLANTING AND PRE-EMERGENCE TREATMENTS

M.F. Trevett, H.J. Murphy, and William Gardner[1/]

Introduction

This paper is a report of the effectiveness of the herbicides listed in Table 1 on broadleaf weed control in white potatoes.

Procedure

Potatoes were planted in a loam soil and spaced 12 inches in rows 42 inches apart. The pre-emergence and at-planting blocks were planted to Katahdins 11 May, 1964. The herbicide incorporated block was planted to Chippewa's 2 June, 1964. Herbicides had been applied and rototilled in to a depth of 2-4 inches, 28 June, 1964.

Treatments were replicated six times in randomized blocks of single-row plots paired with untreated checks. Herbicides were applied with one pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. Potatoes were hilled three times. The final hill was approximately 24 inches wide at the base, 10 inches high, and 6 inches wide at the top.

The principal weeds were: Wild rutabaga (*Brassica rapa* L.), Red-root pigweed (*Amaranthus retroflexus* L.), and Lambsquarters pigweed (*Chenopodium album* L.).

Results

Herbicides applied at planting - Table 2:

Four pounds GS-14260 applied at planting, 4 pounds Tupersan plus 2 pounds Linuron applied at planting, and 4.5 pounds DNBP plus 7.4 pounds Dalapon applied pre-emergence produced significantly higher yields than planting applications of

4 pounds Amiben not raked in
4 pounds of Amiben raked in
1 and 2 pounds GS-14260
6 pounds Tupersan

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but did not differ significantly in yield from a planting application of 4 pounds Tupersan plus 4.5 pounds DNBP applied pre-emergence or from planting applications of

2 pounds Linuron, 2 pounds Linuron plus 6 pounds Tupersan
8 pounds Amiben not raked in
3 pounds Prometryne
8 pounds Amiben raked in
Hand hoed checks

Yields generally followed broadleaf weed control: high percent control, high yield.

Combinations of Tupersan and Linuron increased neither yields nor weed control over Linuron alone. This was expected since annual grasses were not present in sufficient numbers to be competitively significant. The data do indicate that the yield of Katahdin potatoes will not be decreased by combination treatments of 6 pounds Tupersan plus 2 pounds Linuron per acre.

Herbicides applied pre-emergence - Table 3:

The treatments:

6 pounds Tenoran raked in one-half inch
4.5 pounds DNBP plus 7.4 pounds Dalapon
3 pounds UC-22463, applied at emergence

gave significantly higher yields than hand hoed plots and

1 and 2 pounds B-377
2 and 4 pounds C-2059

but did not differ significantly in yield from

4 pounds Tenoran raked in one-half inch
4.5 pounds DNBP
3 pounds B-377.

C-2059 gave excellent broadleaf weed control at the 2 and 4 pound per acre rate, but retarded vine growth of Katahdins.

Herbicides applied preplanting and incorporated - Tables 4 and 5:

Preplanting application and incorporation of 4 and 6 pounds of Diphenamid, and combinations of 0.5 pounds Trifluralin plus 2 pounds of Diphenamid, and 1 pound Trifluralin plus 4 pounds of Diphenamid did not differ significantly in effect on yield from hand hoed plots or from the standard treatment of 3 pounds DNBP per acre plus 5 pounds of Dalapon: Table 4.

One and three pounds of Trifluralin gave significantly lower yields than the other chemical treatments. The low yield from Trifluralin alone resulted from inadequate control of Wild Rutabaga, Table 5. When Wild rutabaga was not included in the broadleaf control ratings, 3 pounds of Trifluralin per acre gave 99.3 percent control, and one and one-half pounds gave 88.7. When Wild rutabaga was included in the ratings, 3 pounds Trifluralin gave 31.3 percent control and one and one-half pounds gave 33.3.

Conclusions

In an area where weeds do not become a serious problem after the last hilling of potatoes, DNBP plus Dalapon treatment continues to be the standard of excellence. As in previous years yields from this treatment are frequently equalled by other materials or combinations of materials but they are not usually surpassed.

Prometryne at three pounds per acre and GS-14260 at 4 pounds per acre are promising materials. Amiben at 8 pounds per acre incorporated after planting, gave yields not statistically lower than standard.

Combinations of Tupersan and Linuron, as high as 6 pounds per acre of Tupersan and 2 pounds of Linuron were tolerated by Katahdins giving yields statistically equivalent to standard.

In the current tests, one-half pound of Trifluralin per acre plus 2 pounds Diphenamid applied preplanting and incorporated, gave as high yields as 6 pounds of Diphenamid. Trifluralin alone did not adequately control Wild Rutabaga.

Table 1. Herbicides Used in White Potato Tests.

Designation	Active Ingredient
AMIBEN	3-amino-2,5-dichlorobenzoic acid
B-377	2,4-Dinitrophenyl-(2'-sec-butyl-4',6'-dinitrophenyl)carbonate
C-2059	N-(3-trifluoromethylphenyl)N',N'-dimethyl-urea
DALAPON	2,2-dichloropropionic acid
DIPHENAMID	N,N-dimethyl-2,2-diphenylacetamide
DNBP	4,6-dinitro-ortho secondary butylphenol
GS-14260	A Geigy Product
LINURON	3-(3,4-dichlorophenyl)-1-methoxy -1-methylurea
PROMETRYNE	2,4-bis(isopropylamino)-6-methylmercapto-s-triazine
SD-9515	A Shell Product
TENORAN (C-1983)	N-4(P-chlorophenoxy)-phenyl-N',N'-dimethylurea
TRIFLURALIN	a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-P-toluidine
TUPERSAN	1-(2-methylcyclohexyl)-3-phenylurea
UC-22463	A Union Carbide Product

Table 2. Pounds of Tubers Per 25 Feet of Row Following At-Planting and Pre-Emergence Treatments in White Potatoes.

Treatment number and acre rate of active ingredient and time of application	Means: Pounds of tubers per 25' of row	Percent broadleaf weed control
9. 1# GS-14260, PL[1]	30.08a[2]	93.9a[2]
2. (4.5# DNBP + 7.4# Dalapon) PRE[1]	29.47a	94.0a
5. (4# Tupersan + 2# Linuron) PL	29.30a	97.0a
16. 2# Linuron, PL	28.37ab	95.6a
6. (6# Tupersan + 2# Linuron) PL	25.04abc	96.4a
14. 8# Amiben, PL, not raked in	25.00abc	64.3 bc
10. 3# Prometryne, PL	23.80abcd	76.3ab
12. 8# Amiben, PL, raked in 1/2 inch	23.30abcd	59.3 bcd
1. Hand hoed	23.07abcd	96.1a
3. 4# Tupersan, PL + 4.5 DNBP, PRE	23.06abcd	93.6a
13. 4# Amiben, PL, not raked in	21.54 bcd	48.6 cd
11. 4# Amiben, PL, raked in 1/2 inch	21.12 cd	47.2 d
8. 2# GS-14260, PL	19.80 cd	51.4 cd
7. 1# GS-14260, PL	17.60 de	22.3 e
4. 6# Tupersan, PL	12.81 e	12.3 e
17. Check, not hand hoed	12.44 e	0.0 f
L.S.D. 5%	5.74	19.0

1/ PL = applied at planting
PRE = applied pre-emergence.

2/ Duncan's Multiple Range Test.

Table 3. Pounds of Tubers Per 25 Feet of Row Following Pre-Emergence Treatment of White Potatoes.

Treatment number and acre rate of active ingredient	Means: Pounds of tubers per 25' of row	Percent broadleaf weed control
5. 6# Tenoran - raked in 1/2 inch	27.90a 1/	93.3a
2. 4.5# DNBP + 7.4# Dalapon	27.23a	88.3a
3. 3# UC-22463-EM 2/	25.22a	77.6a
4. 4# Tenoran - raked in 1/2 inch	23.88ab	77.5a
15. 4.5# DNBP	21.98abc	80.5a
14. 3# B-377	20.83abc	45.0 b
1. Hand hoed	17.35 bcd	95.8a
13. 2# B-377	16.60 cd	21.0 c
6. 2# C-2059	16.03 cd	87.8a
12. 1# B-377	13.32 d	6.8 c
7. 4# C-2059	6.46 e	99.0a
L.S.D. 5%	6.13	18.5

1/ Duncan's Multiple Range Test.

2/ Applied at emergence, not pre-emergence.

Table 4. Pounds of Tubers Per 25 Feet of Row Following Preplanting Treatments in White Potatoes.

Treatment number and acre rate of active ingredient	Means: Pounds of tubers per 25' of row
1. Hand hoed	38.23a[2]
6. 6# Diphenamid PP[1]	35.50a
2. (3# DNBP + 5# Dalapon) PRE[1]	35.20a
8. (1# Trifluralin + 4# Diphenamid)PP	33.48a
7. (0.5# Trifluralin + 2# Diphenamid) PP	32.68a
5. (4# Diphenamid) PP	31.18a
9. Check - not hand hoed	21.53 b
3. 1.5# Trifluralin PP	19.63 b
10. Check - not hand hoed	16.56 bc
4. 3# Trifluralin PP	11.20 c
L.S.D. 5%	7.39

1/ PP = preplanting.
PRE = applied pre-emergence.

2/ Duncan's Multiple Range Test.

Table 5. Percent Control of Broadleaf Weeds in Potatoes Following Preplanting Incorporation of Herbicides. Ratings Made 24 August '64.

Treatment Acre rate of active ingredient	*Brassica* not included[3] Treatment means using arcsine transformation	*Brassica* not included[3] Untransformed Means - %	*Brassica* included[4] Means: arcsine transformation	*Brassica* included[4] Untransformed Means - %
3# Trifluralin	74.2a[2]	92.3	33.8 b[2]	31.3
1# Trifluralin + 4# Diphenamid	71.9ab	90.0	57.4a	70.7
1.5# Trifluralin	70.7abc	88.7	35.0 b	33.3
6# Diphenamid	63.0abcd	78.5	55.5a	67.3
3# DNBP + 5# Dalapon, PRE[1]	61.1 bcde	75.8	56.3a	69.0
0.5# Trifluralin + 2# Diphenamid	58.7 cde	70.8	44.5ab	49.6
Hand hoed	51.9 de	61.3	55.4a	66.8
4# Diphenamid	50.4 e	58.5	40.4 b	43.0
L.S.D. 5%	10.8		11.4	

1/ PRE = pre-emergence.

2/ Duncan's Multiple Range Test.

3/ *Brassica Spp.* not included in ratings.

4/ *Brassica Spp.* included in ratings.

POTATO VINE KILLING IN MAINE - 1963

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 1963 growing season. Evaluation of harvested tubers were made during the 1963-64 storage seasons.

MATERIALS AND METHODS:

Ten potato vine desiccants were tested at Presque Isle, Maine during 1963. The purpose of this trial was to determine the effectiveness of these desiccants for potato vine destruction prior to harvest and the subsequent effects on tubers harvested from these plots.

All chemicals were applied in 90 gallons of water per acre to actively growing potato vines on the dates indicated in Table 1. A small compressed air sprayer, equipped with a two-nozzle brush type boom was used for application to single row plots. The experimental design was a randomized block containing six replicates of each treatment.

Using a relative kill rating system of 1 to 5 as indicated in the footnotes of each table, ratings were made at two time intervals after application of the desiccants.

Approximately twenty pounds of tubers were saved from each plot at harvest time and placed in 50° F. storage for examination during the winter months. Storage examination consisted of snipping or slicing the stem end of each tuber and classifying each tuber as to percent of vascular ring showing discoloration. The stored tubers were also examined for possible external discolorations which might have been caused by vine-killing chemicals. In addition, tuber samples were made available to each company who supplied desiccants for examination and residue analysis if they so desired.

The snipped samples were returned to 38° F. and planted in a replicated emergence trial in 1964 to determine if any of the desiccants had any affect on sprouting of tubers when replanted for seed.

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RESULTS AND DISCUSSION:

Data presented in Table 1 indicate the effect of several desiccants on vines and tubers of the Katahdin variety.

U.C. 20299 (PREP) at the 2.5 pound rate and Ametryne 25E at the 2 pound rate were as effective as the standard sodium arsenite recommendation of 8 pounds of arsenic trioxide per acre.

Paraquat and Diquat were effective potato vine desiccants at all rates of application.

Banvel-D, Ametryne 50W, and both Prometryne formulations were unsatisfactory potato vine desiccants in Maine during 1963.

Emergence of plants from seed pieces cut from tubers harvested from Banvel-D plots was apparently affected as shown in Table 1. The plants which did emerge were stunted, chlorotic, and had leaves which exhibited extreme rolling.

Internal discoloration due to vine killing chemicals in 1963 was of minor importance. Data in Table 1, however, do indicate that Banvel-D and possibly the high rate of Paraquat probably were causing some added internal discoloration to the tubers.

Table 1. Effect of Several Chemicals Used for Potato Vine Killing - 1963
Aroostook Farm, Presque Isle, Maine

Treatments 1/		Katahdin Variety Kill ratings 2/		Percent Internal discoloration			Percent emergence
Material	Rate per Acre	Aug. 28	Sept. 5	Slight	Medium	Severe	1964
No treatment		1.0	1.0		0.3		99
U.C. 20299 3/	2 lbs. 4/	3.9	4.6	0.4			100
U.C. 20299	2½ lbs. 4/	4.5	5.0	0.6			100
Banvel-D	1 qt.	2.0	2.3	2.3			95
Banvel-D	2 qts.	2.5	2.7	1.6			90
Ametryne 25E	2 lbs.	4.3	5.0				100
Ametryne 50W	2 lbs.	2.0	2.5	0.3	0.1		100
Prometryne 150E	2 lbs.	1.0	1.0	0.8			100
Prometryne 50W	2 lbs.	1.0	1.0	0.5			100
Paraquat	1 pt.	4.5	5.0	0.3			100
Paraquat	1½ pts.	4.7	5.0	0.3			100
Paraquat	3 pts.	5.0	5.0	1.1			96
Diquat	1½ pts.	4.5	5.0				99
Diquat	3 pts.	4.7	5.0	0.3			100
Sodium arsenite	8 lbs.	3.7	4.6				100
Premerge	2 qts. 5/	3.6	3.8	0.5			99
L.S.D. (0.05)		0.2	0.8				
(0.01)		0.3	1.1				

1/ Materials applied August 21, 1963.
2/ Kill rating code (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.
3/ U.C. 20299 now called PREP.
4/ Tergital used as a spreader-sticker.
5/ Used in combination with 5 gals. of fuel oil plus 1 pt. of emulsifier.

POTATO WEED CONTROL[1]

R. L. Sawyer and S. L. Dallyn[2]

Introduction

The cultural practices for Long Island potatoes do not lend themselves to the acceptance of a pre-emergence program which requires that the ground remain undisturbed after application. This is partly due to the use of supplemental nitrogen, also to the slow accumulation of a hill for ground storage of potatoes after maturity until temperatures become low enough for rapid cooling of the stored crop; thus major emphasis has been placed on late season weed control. Recently several materials have become available which may be pre-emergence applied and the soil continued to be cultivated without destroying the effectiveness of weed control. Such materials might be very desirable on Long Island and are now part of the program.

Method

The weed control experiments were run at two locations...one at the Research Station to determine the effect on yield and on storage and cooking quality; the herbicides were also applied at a grower location where there is commonly a severe weed problem. Materials whose effectiveness might not be destroyed by cultivations were applied at the time the planting ridges were smoothed down, "drag-off". The remaining materials were applied just before or after last cultivation, depending on whether soil incorporation was necessary.

Katahdin potatoes were planted at the Research Station on April 27, 1964, and fertilized with 2900 pounds per acre of a 6-12-6 ratio. There were five weeding and cultivations for weed control and the hilling operation. Potatoes were irrigated seven times during the growing season due to the sparseness of natural rainfall for this season. The chemicals in Table 1 for the drag-off application were applied on May 28, 1964. The chemicals in Table 2 for the lay-by application were applied on June 29 and 30, 1964. Potatoes were harvested September 11, 1964 and samples placed in storage for quality determinations in the 1964-65 storage season.

Results

Foliage type has been recognized as a major factor determining the extent of the weed problem. Green Mountain variety, with dense foliage, consistently gives little if any problem whereas Katahdin, with its sparse foliage, practically always has a problem. The delay in planting season caused by spring rains and the cold weather during the time vines are usually breaking over, gave a foliage type to Katahdin which contained the weed problem in practically all of the Long Island area for the 1964 season.

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At none of the locations could weed control be satisfactorily determined; thus for both the drag-off and the lay-by experiment, effects of chemicals on the potato plants were the only results obtained. These are given in Tables 1 and 2. Although Dymid retarded early growth, none of the materials affected yield of potatoes adversely either in the lay-by or drag-off application.

The chemicals reported on page 167 of the Proceedings of the Northeastern Weed Control Conference of 1964 were followed through storage for storage quality and chipping quality. None of the materials had any adverse effect on chipping, shrinkage, sprouting or black spot of potatoes.

Table 1. Effect of herbicides applied at lay-by on yield of Katahdin potatoes.

Material	Lbs/A	US No. 1 Cwt/A	2-3½" Cwt/A
1. UC 22463G 15/30	4	342	305
2.	8	366	319
3. UC 22463G 30/60	4	370	329
4.	8	376	321
5. Enide, G	4	407	358
6.	6	368	292
7. EPTC, G (before last cult.)	4	348	301
8. " " "	6	338	292
9. B377	3	355	297
10.	6	342	302
11. BP 9	4	378	307
12.	8	398	305
13. SD 9515	1	420	376
14.	2	372	311
15. CP 31675 (before last cultivation...	2	357	312
16. " "	4	340	220
17. CP 31675	2	356	280
18.	4	397	317
19. Check		397	328
		N.S.	N.S.

Table 2. Effect of herbicides applied at drag-off on yield of Katahdin potatoes.

Materials	Lbs/A	US No. 1 Cwt/A	2-3½" Cwt/A
1. Dymid	2	360	270
2.	4	361	282
3. EPTC	4	360	272
4.	6	317	250
5. Randox	4	356	280
6.	6	311	255
7. Diphenamid	4	348	276
8. Treflan	1	340	247
9.	2	311	209
10. Trefmid	2½	349	262
11.	5	348	275
12. ENIDE	4	366	261
13.	6	328	268
		N.S.	N.S.

POTATO VINE KILLING[1]

R. L. Sawyer and S. L. Dallyn[2]

Introduction

Potato vine killing concerns the trash problem of both vines and late weeds in potato fields. Major consideration in this program has been given to materials which might enhance the physiology of the potato as well as eliminate the trash. The ideal chemical was considered to be one which would trigger normal maturity functions for the potato plant and tuber, possibly giving a better internal and external tuber quality at harvest and through storage than a material which simply killed the vines and the weeds quickly.

The main objective has been to find chemicals which could trigger maturity with a slow initial kill. At the end of a 7 to 10 day period, the total kill would be similar as with fast acting materials. Thus, major emphasis has been given to type of kill and the quality of the potatoes at harvest and through storage.

Method

Katahdin and Kennebec potato varieties were planted on April 21, 1964, and fertilized with 2900 pounds per acre of a 6-12-6 ratio. There were five weedings and cultivations for the weed control and killing operation. Potatoes were irrigated seven times during the growing season due to the spareness of natural rainfall for this season. The chemicals listed in Table 1 were applied on August 24 to Katahdins and August 25 to Kennebecs. The materials in Table 2 were applied to Russet Burbank potatoes on September 15 which had been planted in early May and still had good green foliage. All potato foliage was actively growing at the time of application of the materials. Two types of potatoes were used to obtain the effect of chemicals on sparse foliage, typical of Katahdin variety, and dense foliage, typical of Kennebec variety. Potatoes were harvested on September 28, 1964.

The vine kill was rated 3, 5 and 8 days from application according to the following system:

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

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Results

The yield data indicate that the materials were applied at a time when there was still good growth and translocation to the potato. The Katahdin check was the highest yielding, and the Kennebec check was highest of all except two treatments. The speed of kill, if vines are actively growing, could result in yield differentials. There was a similar differential between check and chemicals for both the slow and fast killers in general.

Materials which gave a similar fast effective kill as sodium arsenite, the standard chemical now in use on Long Island, were Ortho 831 at the 2, 4 and 8 pounds per acre rate with both Kennebec and Katahdin. Diquat at .25 and .50 pounds per acre did an excellent job with Katahdin but was inferior to sodium arsenite with Kennebec. Paraquat at the .50 pounds per acre was similar to sodium arsenite with Katahdin but neither of the rates were satisfactory with Kennebec. Chipman 2929 with diesel oil at 4 and 6 pounds per acre was similar to sodium arsenite with Katahdin and Kennebec but without the diesel oil was only satisfactory on the Katahdin foliage. Dow General and Premerge with diesel oil were similar to sodium arsenite with Katahdin variety but not with the Kennebec variety. Anser 138 was a little slower in initial kill than sodium arsenite at both the 3 and 5 pound level. Final kill was similar to sodium arsenite with Katahdin variety but not with Kennebec variety.

Prep continues to look the most promising in terms of the physiological objectives of this program. With or without a spreader-sticker, Prep at 4 and 6 pounds gave a much slower initial kill than sodium arsenite at 6 and 8 pounds yet the final kill was similar to sodium arsenite. It is particularly noteworthy that this material reacted similarly with the Kennebec's dense foliage and the Katahdin's sparse foliage. Even sodium arsenite showed a considerable effect due to variety at the 4 pound dosage. Shed-A-Leaf with Katahdin variety was the only other material which had a slow initial kill but an eventual kill approaching that of sodium arsenite.

The vine killing experiment with Russet Burbank was aimed mainly at the possibility of combining fertilization of the annual cover crop with vine killing. Nitrogen materials were compared to sodium arsenite. G.C. 7887 which was also included did not give sufficient kill at the dosages used. Uran gave little if any kill at either dosage or water concentration. Ammonium nitrate gave enough of a kill at the lowest water concentration to indicate some possibility dependent on the variety and stage of maturity of the vines. There was a definite difference in the amount of kill dependent on the water concentration with ammonium nitrate.

Summary

1. In terms of the physiological objectives of this experiment, Prep looked most promising. It gave a slow initial kill but the 8-day kill was similar to sodium arsenite with both Katahdin and Kennebec varieties.

2. The type of foliage of a given variety had considerable effect on the vine killing effect of the chemical with most of the materials used including sodium arsenite.

3. Although ammonium nitrate did not give the total kill desired, it appeared to have some possibilities of combining vine killing and cover crop fertilization under certain conditions.

Table 1. Effect of several chemicals on yield and speed of vine killing of two potato varieties.

Materials	Lbs/A	Cwt/A US #1 Katahdin	Cwt/A US #1 Kennebec	Cwt/A 2-3½" Katahdin	Cwt/A 2-3½" Kennebec	Vine Kill Rating* Katahdin	Vine Kill Rating* Kennebec
1.Ortho 831.....	2	366	300	259	297	6.0-7.0-8.0	7.0-8.0-8.0
2.	4	366	351	269	320	6.0-6.5-8.5	6.0-7.5-7.5
3.	8	353	333	264	302	7.0-7.0-8.5	6.0-6.5-7.5
4.Diquat	.25	337	348	284	302	6.0-7.5-8.5	4.0-5.0-6.0
5.	.50	389	305	289	302	6.0-7.0-8.5	4.0-5.5-7.0
6.Paraquat	.25	369	338	287	312	4.0-6.0-6.0	2.0-2.5-2.5
7.	.50	338	289	250	238	6.0-6.5-8.0	5.0-5.5-6.0
8.Prep	2	366	310	266	292	2.0-4.0-5.0	2.5-5.0-5.5
9.	4	351	335	243	302	4.0-6.0-7.0	4.0-6.0-7.5
10.	6	333	348	261	317	4.5-6.0-8.0	4.0-6.0-7.5
11.Prep + Tergi-tol	2	381	335	251	297	2.0-4.0-6.0	2.0-4.5-5.5
12.	4	346	333	236	292	4.0-5.5-7.5	3.5-6.0-7.0
13.	6	328	330	244	305	4.0-6.0-8.0	3.5-6.0-7.5
14.Chipman 2929...	4	305	276	237	284	6.0-6.5-8.0	4.0-5.0-5.5
15.	6	279	333	218	315	6.5-7.0-8.0	5.0-6.0-6.5
16.Chipman 2929 + diesel oil....	4	374	230	248	230	7.0-7.5-8.0	6.0-7.5-8.0
17.	6	358	345	264	315	7.0-7.5-8.0	6.5-7.0-8.0
18.Hydrogen Cyana-mid.....	2.50	381	323	266	302	2.5-3.5-3.5	2.0-3.0-3.0
19.	5.00	369	346	269	307	4.5-5.5-6.5	4.0-5.0-5.0
20.Shed-A-Leaf	10	361	335	261	297	4.0-5.5-7.0	4.0-6.0-6.0
21.	15	369	338	259	310	3.5-5.0-6.5	5.0-6.5-7.5
22.	20	381	366	287	328	3.5-5.0-7.0	4.5-6.0-6.5
23.Dow General 3 pts Diesel oil 5 gal		351	343	271	330	5.5-6.0-7.5	4.0-5.5-6.5
24.Premerge 2½ qts Diesel oil 5 gal		358	274	264	259	6.0-7.5-8.0	4.0-4.5-6.0
25.Sodium Arsen-ite.....	4	325	389	282	310	7.0-8.0-8.0	2.0-2.0-2.0
26.	6	369	325	271	307	7.0-7.0-8.0	6.5-7.5-7.5
27.	8	384	366	266	328	6.5-6.5-8.0	6.5-7.5-8.0
28.Anser 138.....	3	335	392	253	366	5.5-7.0-8.0	4.5-5.5-6.5
29.	5	366	317	256	292	5.3-5.5-7.5	4.5-6.0-7.5
30.Check.....		399	376	271	297	1.0-1.0-1.0	1.0-1.0-1.0
		NSD	NSD	NSD	NSD		

*The three figures indicate vine kill at 3, 5 and 8 days from chemical application.

Table 2. Effect of several chemicals on yield and speed of vine killing with Russet Burbank Variety

	Lbs/A	Gallons Water/A	US #1 Cwt/A	2-3½" Cwt/A	Vine Kill Rating 2 days	5 days	8 days
Ammonium Nitrate	140	35	294	182	4.5	4.5	6.0
" "	200	35	300	166	4.5	5.5	6.0
" "	140	70	284	108	3.0	3.0	3.5
" "	200	70	346	159	4.0	4.0	5.0
Uran	15	35	346	156	1.0	1.0	1.0
"	30	35	376	174	1.5	2.0	2.0
"	15	70	302	172	1.5	1.5	1.5
"	30	70	297	115	2.0	2.0	2.0
Na As	6	70	340	179	7.0	7.5	8.0
"	8	70	312	169	8.0	8.0	8.5
G.C. 7887	10	70	238	123	2.0	2.5	3.5
"	15	70	238	77	3.5	4.0	5.5
Check			297	172	1.0	1.0	1.0

QUACKGRASS CONTROL PRECEDING POTATOES

LeRoy P. Stevens [1]

Quackgrass (*Agropyron repens*) causes considerable damage to potato crops by competition and by direct tuber injury from creeping rhizomes. This has been true at the West Virginia University Experiment Farm at Arthurdale, West Virginia for several years. Yield comparisons made in 1963 of two adjacent one-acre-plots on Atkins sandy loam (which had received the standard treatment with dinitro and dalapon) showed that Plot A yielded 398 bushels of potatoes, (51% U.S. No. I) and Plot B yielded 663 bushels (86% U.S. No. I) grade. In each plot, sixty stand counts were taken two weeks before potato harvest. Plot A had an average of 21 quackgrass plants per square foot, and Plot B had no quackgrass.

From this, it was concluded that heavy quackgrass stands greatly reduce yields and grade, and that the chemicals used on potatoes are not sufficient to control quackgrass.

MATERIALS AND METHODS

In 1963, work was initiated in an effort to eradicate quackgrass by using atrazine and amino triazole in one of three fields used in the potato rotation without greatly upsetting the rotation. A consistant rotation should be maintained for disease control. The soil used in all treatments was Atkins sandy loam, which was tile drained. Quackgrass stand counts on 9 acres were found to be of an average density of 19 plants per square foot. (All densities given are an average of 60 counts per acre, using a 12" x 12" square frame dropped at random.) Spray materials were applied with a tractor mounted sprayer, using a 20-foot spray boom.

RESULTS AND DISCUSSION

1963 Growing Season: On April 24, 2.5 lbs. (per acre ai) of atrazine and 3.5 lbs. (per acre ai) of amino triazole were applied as a pre-plow spray treatment. On May 10, the land was plowed. The seed-bed was prepared, and planted to field corn (Ohio M-15) by May 12. The field was again sprayed with 1.5 lbs. of atrazine as a post-emergence spray on June 6. One cultivation was made on June 28. The treated area yielded 10,540 lbs. per acre of ear corn at 29% moisture.

In October a quackgrass stand count averaged .03 plants per square foot. Quackgrass could be found along the field borders and in isolated spots throughout the field. The crop residues were chopped with a rotary mower and left on the field for winter cover.

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1964 Growing Season: On April 17, 1964, 2 lbs. of atrazine was applied as a pre-plow treatment. The field was plowed, fitted and again planted to corn the week of May 11. One and one half lbs. of atrazine was applied as a post-emergence spray on June 10. No cultivation was made. In October, 10,800 lbs. per acre of ear corn at 27% moisture was harvested.

When stand counts were taken in late October, quackgrass was found only in the field borders, where it may have been moved in by tillage methods.

Previous work on Atkins sandy loam soil has shown that potato yields were as high in fields treated two years before planting with 7 lbs. of atrazine, as in fields where no atrazine was used within four years.

SUMMARY

Quackgrass (*Agropyron repens*) competes heavily with potatoes for nutrients; reduces the crop market value; and greatly decreases the yield per acre. Yield comparisons of two adjacent one-acre-plots on Atkins sandy loam soil (treated with dinitro and dalapon) gave a 59% grade reduction (U.S. No. I) and 60% yield reduction where the average density of quackgrass was 21 plants per square foot, as compared with no quackgrass.

In 1963, atrazine (2.5 lbs. per acre ai) and amino triazole (3.5 lbs. per acre ai) was applied as a pre-plow treatment to a 9-acre field on April 24. The field was planted to corn, and treated again with 1.5 lb. of atrazine on June 6. Quackgrass stand counts taken in October gave a reduction from 19 plants per square foot to .03.

Further treatments in 1964, using 2 lbs. of atrazine (pre-plow treatment) and 1.5 lb. of atrazine (post-emergence treatment on corn) reduced the quackgrass stand count to zero, except in the field borders where it may have been moved in by tillage methods.

Previous work has shown that potato yields on Atkins sandy loam soil were as high in fields treated two years before planting with 7 lbs. of atrazine, as in fields where no atrazine was used within four years.

These results indicate that quackgrass can be controlled on Atkins sandy loam soil by judicious use of atrazine and amino triazole, and not greatly upset the rotation used or reduce yield and grade of potatoes.

WEED CONTROL IN STRAWBERRIES[1]

S. L. Dallyn and R. L. Sawyer[2]

Introduction

Over the past several years a relatively large number of herbicides have been examined at the Long Island Vegetable Research Station for their effectiveness in strawberry production. Approximately ten materials have shown definite promise under our conditions in this area. For various reasons -- replacement by superior chemicals, lack of manufacturer's interest in labeling, etc. -- this number was cut to about five in 1962 and the decision made to start more intensive study on them. This number has been maintained since that time though several changes in the actual herbicides involved have been made.

Currently we believe Dacthal, Eptam, and Diphenamid are the three best herbicides for recommendation. R-1607 and Trifluralin remain in our intensive program as results with them have looked fairly promising. This selection, based on our results, would appear to be well substantiated by other work within the northeast region. Alder (1) reported in 1962 that Diphenamid up to 8 lbs. per acre was safe and that its effectiveness was not destroybed by shallow cultivation. Schubert (8,9,10) over the interval 1961-64 has reported favorably on Diphenamid, EPTC and R-1607. Ilnicki (6,7) obtained outstanding results with Diphenamid at 6-8 lbs., Dacthal at 10 lbs., R-1607 at 6 lbs., EPTC at 3-6 lbs., and Trifluralin at 2-6 lbs. Some damage was observed at the highest rates of EPTC and Trifluralin. Bailey (2) reported only fair results with EPTC at 2 lbs. per acre but the rate used was obviously too low. Stadelbacher (11,12) found that Diphenamid and Trifluralin reduced numbers of runners set. In 1964 he reported Trifluralin and R-1607 too toxic under their conditions but Diphenamid satisfactory if application delayed until the plants were well established -- 42 days. Dallyn (4) rated EPTC, Diphenamid, Dacthal and Trifluralin high in 1963 used as either single or double applications. In the case of the latter material some plant damage was caused by a double application and yields were also reduced -- 6450 lbs. per acre vs. 8558 for the check. Work on the project described in this paper was started in 1962 (5) and has continued through the present time.

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[1] Paper No. 515, Vegetable Crops Dept., Cornell University, Ithaca, N.Y.

[2] Long Island Vegetable Research Station, Riverhead, New York

Objectives

The object of the present series of experiments was to determine the maximum usefulness of selected herbicides in strawberry production. Through the use of repeated applications it was hoped to obtain satisfactory weed control through the period from plant establishment in the first year to harvest of the second year. On the basis of what was known about the materials involved it was expected this would require spring, summer and late fall treatments. Bell (3) has reported on a related project where late October and November applications of herbicides were made for weed control during the winter and the following spring. He found Diphenamid to be the most promising of the materials he worked with.

Methods

In all experiments the mother plants were set two feet apart in rows 34 inches apart, and the beds maintained at a 12-14 inch width. In this method of culture, runners are of secondary importance and may explain the difference between our results with Diphenamid and R-1607, and those of Stadelbacher (11). Soil type in all cases was a Sassafras loam.

Details of the 1962-63 experiment have already been given (5).

1963-64 Experiment:

Three varieties, Jerseybelle, Vesper and Red Glow were set May 15. Fertilization consisted of 1000 lbs. per acre 6-12-6 disked in before setting plus two sidedress applications of 40 lbs. nitrogen (NH_4NO_3) per acre -- June 27 and August 15. Herbicide treatments were applied June 18, August 6 and October 23. Treatment No. 1, Dacthal pre-setting, was applied May 15. Check plots were hand weeded so that no competition from weeds occurred. Immediately preceding each treatment date all plots were rated for weed control, then cultivated and hoed. Major weeds present, in approximate order of importance, were barnyard grass, crabgrass, purslane, chickweed, smartweed and lambs-quarters. Tillam, Eptam and R-1607 were incorporated; the other materials were applied and left on the soil surface. A randomized block design with three 24' replications was used. Harvesting started June 3, 1964, and continued through July 6, a total of 15 pickings.

1964-65 Experiment:

Jerseybelle, Surecrop and Red Glow were set May 12. Cultural treatments were the same as for the 1963-64 crop. Tillam was dropped on the basis that it probably would not be registered for strawberries. Two experimental materials (see Table 2) were added on a preliminary scale.

Results and Discussion

The 1962-63 results were promising for single and double applications of Tillam, 4 lb/A, Eptam 4 lbs., Zytron 20 lbs., Dacthal 12 lbs., and Diphenamid, 6 lbs. Trifluralin at 3 lb/A looked good in a single application but caused some yield reduction when used twice (5).

Results of the 1963-64 work are given in Table 1.

Table 1. Effects of herbicides on weed control, and yield of strawberries, 1963-64 crop year

Treatment	Weed Control Rating[1]			Yield #1 Fruit - lbs/A		
	Aug. 5	Oct. 22	May 25	Jerseybelle	Vesper	Red Glow
1. Dacthal 12 lbs pre-setting.....	4.0	3.1	2.0	18,169	16,564	5842
2. Dacthal 12 lbs 6/18	4.0	3.0	2.0	24,845	14,830	5971
3. Dacthal 12 lbs 6/18 & 8/6.....	4.0	4.1	3.8	20,351	13,610	7961
4. Dacthal 12 lbs 10/23	---	---	4.0	21,571	18,554	5329
5. Dacthal 12 lbs 6/18, 8/6 and 10/23.....	4.1	4.2	4.2	19,645	17,270	6869
6. Tillam 4 lbs 6/18	4.0	3.6	3.0	16,050	17,527	5585
7. Tillam 4 lbs 6/18 & 8/6	4.0	4.2	4.2	21,443	15,280	6099
8. Tillam 4 lbs 10/23	---	---	4.0	16,885	16,371	7511
9. Tillam 4 lbs 6/18, 8/6 and 10/23	3.9	4.2	4.3	22,470	17,141	7511
10. Eptam 4 lbs 6/18	4.2	3.9	2.9	18,811	17,398	5393
11. Eptam 4 lbs 6/18 & 8/6	4.2	4.2	3.8	18,554	16,435	6484
12. Eptam 4 lbs 10/23	---	---	3.8	20,287	15,857	8795
13. Eptam 4 lbs 6/18, 8/6 and 10/23	4.3	4.3	4.2	17,719	16,756	6035
14. Diphenamid 6 lbs 6/18	4.6	4.2	3.8	20,159	16,050	8667
15. Diphenamid 6 lbs 6/18 & 8/6.....	4.3	4.3	4.0	14,509*	16,178	5714
16. Diphenamid 6 lbs 10/23	---	---	3.9	16,885	17,270	5200
17. Diphenamid 6 lbs 6/18, 8/6 and 10/23.....	4.4	4.4	4.3	15,280	15,793	4943
18. Trifluralin 3 lbs 6/18	4.1	3.8	3.1	17,976	16,499	7126
19. Trifluralin 3 lbs 6/18 & 8/6	4.1	4.1	3.5	18,104	16,435	6677
20. Trifluralin 3 lbs 10/23	---	---	3.6	18,939	18,297	5521
21. Trifluralin 3 lbs 6/18, 8/6 and 10/23.....	4.0	4.1	3.6	17,334	16,307	4879
22. R-1607 3 lbs 6/18	3.8	3.4	2.8	17,655	19,260	5521
23. R-1607 3 lbs 6/18 & 8/6	3.7	3.9	3.3	19,902	15,986	5264
24. Check	1.0	1.0	1.0	20,223	16,050	5200

[1] 1- no control
5- complete control

* significantly different from check

All materials under study were effective herbicides. Repeat applications in all cases provided superior control over single treatments indicating the desirability of this method if crop response and chemical residues permit it. Longest residual control was given by Diphenamid. There was some indication, however, that the variety Jerseybelle may have been injured where more than one application was made. Growth of rye cover crop was poor on multiple treatment and late single treatment plots of Diphenamid. Growth in October 1964 was only fair on plots which had received a single application in June 1963 -- sixteen months previously.

Dacthal applied before planting continued to look good. Such a treatment would be a definite contribution to season-long weed control with herbicides.

Weed control ratings for the 1964-65 crop are given in Table 2.

Table 2. Effects of herbicides on weed control in strawberries, 1964-65 crop.

Treatment	Weed Control Rating		
	June 25	July 28	Oct. 26
1. Dacthal 12 lbs pre-setting	4.1	4.0	3.0
2. Dacthal 12 lbs 6/11	4.0	3.8	3.2
3. Dacthal 12 lbs 6/11 and 8/1	4.0	4.0	3.9
4. Dacthal 12 lbs 10/28	---	---	---
5. Dacthal 12 lbs 6/11, 8/1 and 10/28	4.1	4.2	4.0
6. Eptam 4 lbs 6/11	4.0	4.3	3.6
7. Eptam 4 lbs 6/11 and 8/1	4.0	4.3	4.4
8. Eptam 4 lbs 10/28	---	---	---
9. Eptam 4 lbs 6/11, 8/1 and 10/28	4.0	4.0	4.5
10. R-1607 4 lbs 6/11	3.9	4.2	3.4
11. R-1607 4 lbs 6/11 and 8/1	4.0	4.4	4.2
12. R-1607 4 lbs 10/28	---	---	---
13. R-1607 4 lbs 6/11, 8/1 and 10/28	4.0	4.2	4.3
14. Diphenamid 6 lbs 6/11	4.6	4.3	3.9
15. Diphenamid 6 lbs 6/11 and 8/1	4.2	4.3	4.5
16. Diphenamid 6 lbs 10/28	---	---	---
17. Diphenamid 6 lbs 6/11, 8/1 and 10/28	4.3	4.0	4.6
18. Trifluralin 3 lbs 6/11	3.8	3.8	2.6
19. Trifluralin 3 lbs 6/11 and 8/1	4.0	3.8	4.2
20. Trifluralin 3 lbs 10/28	---	---	---
21. Trifluralin 3 lbs 6/11, 8/1 and 10/28	4.0	3.8	4.2
22. Penn. B-377 4 lbs 6/11	4.0	3.0	2.0
23. T.H. 052-H 6 lbs 6/11	4.0	3.8	2.0
24. Check	1.0	1.0	1.0

Results continued to look promising, particularly for the multiple application treatments. There were no visible effects on the strawberries in any of the plots but the 1965 yield data will be needed before any definite conclusions can be made on this.

Summary

1. The following herbicides have looked promising in strawberry production -- Dacthal, Eptam, Diphenamid, Trifluralin, R-1607 and Tillam.

2. Two and three applications per season have shown marked superiority in weed control over single applications. Additional work is required to determine effects on yield. There has been some indication that Trifluralin and Diphenamid used more than once caused some reduction in yield of strawberries.

3. Pre-setting use of Dacthal looked good. Such a treatment would be a definite contribution to full-season weed control with chemicals.

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The Effectiveness of Several Herbicides Applied During the Plant Growing Year of Strawberries and Their Effect on Production

By C. A. Langer[1]

Introduction

Weed control in strawberries has always been an expensive and unpopular operation. Growers are continually searching for labor-saving devices that will increase the net profit. There has been much interest in herbicides for weed control in strawberries during the past few years. Research by university and industry workers has been encouraging and helpful. At New Hampshire this research was designed primarily to evaluate several herbicides for their ability to control weeds in new strawberry beds. After noting results in the first year, it was decided to continue the research through the harvest of the following season to evaluate production data from the several herbicide plots.

Procedure

Weed control plots were established on a commercial fruit farm in New Hampshire. Three rows were chosen for treatment. Each herbicide treatment was replicated three times. Plants of the variety Catskill were set on April 5, 1963, in a loamy sand soil containing some small stones. Each plot was 1/100 acre in size. The plots were carefully cultivated and hoed just prior to application of herbicides. Experimental plots, as well as the rest of the strawberry planting, received one inch of water by irrigation three days after herbicide application. Soil moisture at the time of herbicide application appeared to be uniform on all plots. In each plot, soil was moist, freshly cultivated, and hoed, and free from germinating weeds, as far as could be detected from visual observance. Wettable powders and liquids were applied with a continuous pressure (35 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 control plots were cultivated and hoed on July 11, and the second application of herbicide was applied on July 12. Nothing more was done to the plots in 1963.

In April 1964, the weed control plots were mulched with coarse wood shavings one inch in depth. The purpose of this mulching was mainly to keep the berries clean. The entire planting was sprayed several times to control insect and disease pests. Overhead irrigation was used at two different times to protect berries from frost injury during May. Approximately 1½ inches of water was applied twice each week for six weeks, starting the first of June. Berries were picked every third day. Harvesting records for each 1/100 acre plot was kept separately. At each picking the number of rounded full quarts was tabulated. Since pickers were paid per rounded full quart, volume was chosen as the unit of measure rather than weight.

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Results and Discussion

All treatments showed excellent weed control after application of each herbicide in 1963. On July 11 when plots were all hoed and cultivated, only a few very small weeds were present. The first application of all herbicide materials were effective for ten weeks. The second application was successful in suppressing all new weeds, but it was apparent that a few germinating and growing weeds passed undetected during the July 11 cultivation and hoeing. Within the Dinoben plots moderate runner delay was observed. However, severe winter damage in these plots reduced the plant stand to less than 20 percent of the cultivated checks. Diphenamid 80 percent wettable powder caused very slight and temporary runner delay. There was a definite increase in runner development in the Enide (diphenamid 50% WP) plots as indicated by data in Table 1 and by the increased production shown in Table 2. The increased vigor over the cultivated check plots and the rest of the untreated strawberry field could be partially attributed to the growth of Red Root Pig Weed in untreated plots during August 1963. The weed suppression during early spring and harvest 1964 is certainly worthy of note. In Table 1, the 1964 data show [illegible] clearly how well the weeds were subdued by Enide and Dymid without damage to the strawberry plants or production. Dacthal appeared to be just slightly better than the cultivated checks. Dinoben was superior to all treatments in weed control, but this material was also toxic to the plants.

Table 2 clearly shows that the total production of plants in the Enide (50% Diphenamid) plots out-produced those in all other plots. It is also worthy of note that plants of all herbicide treated plots except Dinoben produced as well or better than the cultivated plots. Dinoben is an excellent weed control material but apparently too destructive to the strawberry plant for commercial use. The cost of weed control in these plots was not part of the planned research, and data was not recorded on hoeing and cultivation time, labor, or chemical costs. It is estimated, based on observations and production figures, that it is no more expensive to use chemicals than it is to cultivate, and it is much easier.

Conclusions

1. It is possible to control weeds in strawberries with six pounds active of either 80% or 50% WP Diphenamid applied as a single application in June following thorough cultivation and hoeing. Application of an inch of water within three days after the herbicide application assured good herbicidal action.

2. Two applications of Dacthal will give excellent control of weeds in strawberries and save several cultivations and hand hoeing.

3. Controlling weeds in strawberries chemically helps utilize labor for use in other very important jobs, otherwise neglected due to lack of labor.

4. The increased production of the Enide plots was not a coincidence, because superior plant growth was noted in these plots during the 1963 growing year.

5. No berries were lost from late frost and very few from insects, disease, or birds. Birds ate an estimated one percent of the berries.

6. Very few berries were lost from drought because of cool nights plus irrigation. Without irrigation the crop would have been cut in half.

7. Cultivated checks produced a calculated 6.1 tons per acre; Dacthal plots produced 5.82 tons; Dymid plots produced 5.98 tons; Enide plots produced 6.85 tons and Dinoben plots produced 2.25 tons.

The Effectiveness of Several Herbicides on Weed Control and Plant Growth in Strawberries During 1963-64

Table 1

No.	Treatment and Formulation	Rate (Lbs/A) 1st App.	Rate (Lbs/A) 2nd App.	Daughter Plant Production[1] and/or Injury				Weed Control*				
		5/27	7/12	7/11	8/6	9/15	10/15	6/20	7/11	8/6	9/15	10/15
					1963							
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	4	3	2	10	10	10	9	9
4.	Dymid WP (Diphenamid 80%)	6	6	4.5	4.5	5	5	10	10	10	9	9
5	Enide WP (Diphenamid 50%)	6	6	5	6	6	6	10	10	10	9	9

		1964					
		5/20	6/10	7/10	5/20	6/10	7/10
1	Cultivated Check	5	5	5	7.5	5	4
2	Dacthal 75% WP	5	5	5	8	6	4.5
3	Dinoben (Amchem 63-102)	2	1	1	9	8.5	8
4	Dymid WP (Diphenamid 80%)	5	5	5	9	7.5	7.5
5	Enide WP (Diphenamid 50%)	6	6	6	9	7.5	7.5

1 5 = Similar to Cultivated Chekcs; 0 = No Runner Formation; 10 = 50 percent more than cultivated checks

* 0 = No weed control; 10 = near perfect; 7.5 = commercial control

Table 2

The Effect of Several Herbicides on Strawberry Yield

Treatment	Plot Size in Acres	Quarts Each Picking											Total Qts.
Cultivated Checks	1/100	4	6	7	8	10	10	9	8	7	6	4	79
"	"	5	7	8	10	11	11	8	8	6	5	3	82
"	"	4	6	10	9	10	11	9	8	7	6	3	83
Dacthal WP	"	2	8	10	9	10	10	9	8	7	5	2	80
"	"	2	7	8	8	9	10	8	8	6	5	3	74
"	"	2	6	8	11	11	10	8	8	7	5	3	79
Dinoben WP	"	1	4	4	3	3	3	2	2	1	0	0	23
"	"	1	3	3	4	4	3	3	4	2	0	0	27
"	"	1	4	6	8	7	5	4	2	1	0	0	40
Dymid WP	"	3	8	9	10	10	10	9	8	8	4	4	83
"	"	2	7	8	9	10	9	9	7	7	5	4	77
"	"	3	7	8	10	12	9	8	7	7	4	2	78
Enide WP	"	4	7	12	11	11	10	9	8	7	8	5	92
"	"	5	7	11	12	10	11	9	8	8	7	5	93
"	"	6	8	10	12	10	10	9	7	7	6	4	89

THE RESPONSE OF THREE STRAWBERRY VARIETIES TO DCPA AND DIPHENAMID -- A PROGRESS REPORT

K. Pliszka, R. D. Ilnicki, and C. R. Smith[1]

ABSTRACT

From preliminary tests at this station it was established that dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) and N,N-dimethyl-2,2-diphenylacetamide (diphenamid) offer excellent possibilities for the control of annual weeds in new transplanted strawberries.

This work was expanded to determine the susceptibility of three popular varieties grown in New Jersey to these two herbicides. It was observed that Midland and Jerseybelle varieties were slightly injured by high rates of diphenamid whereas Sparkle was not affected. DCPA was safe on these varieties.

More critical experiments were conducted in the greenhouse to determine the effects of DCPA and diphenamid on the development of four consecutive leaves and runners. Sparkle was not affected; leaf emergence was slightly delayed in Jerseybelle and Midland by high rates of both herbicides.

In still another experiment where mother plant-daughter plant relationship in Sparkle was studied with diphenamid, it was noted that the developing daughter plant on the runner was affected when the mother plant was treated; however, the growth of the mother plant was somewhat affected when the daughter on the runner was treated.

In an experiment where plants were cultured in nutrient solution it was observed that root growth of sparkle was arrested by a concentration of 1.28 ppm of diphenamid in the solution. Inhibition in root growth of Jerseybelle and Midland was evident at 0.64 ppm of the same herbicide.

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CHEMICAL WEEDING OF STRAWBERRY

Charles J. Noll and Chester W. Hitz[1]

The Pennsylvania State University

The weeding of strawberries is a more difficult task than the weeding of vegetables. The strawberry occupies the land for more than a year. As the runners grow, the area of the crop row continues to widen. Mechanical weeding of the row is difficult and expensive. Chemical weeding has been used extensively. Short-lived herbicides permit the roots of the runners to penetrate the soil, but the treatment must be repeated if weeds are to be kept under control. More persistent herbicides may inhibit the penetration of the runner roots. The primary purpose of these experiments was to control weeds with the least injury to the strawberry plants and runners.

Procedure

These trials were conducted at The Pennsylvania State University Orchard Farm 1 mile east of the campus. The soil is a Hagerstown silt loam. Irrigation was applied as needed.

In the 1963 strawberry planting, the seedbed was prepared April 19. The soil incorporation treatments were applied and incorporated April 21 and the strawberries, variety Midway, transplanted April 22. Post-planting applications of herbicides were made from 3 to 119 days after transplanting and varied from 1 to 3 applications per plot. Individual plots were 12 feet long and 5 feet wide of 5 plants each. Treatments were randomized in each of 7 blocks. Chemicals were applied in a 2 foot band over the row. Five plots were hand weeded twice, and four plots including the check were hand weeded three times. An estimate of weed control was made just prior to the two over-all hand weedings. Records were made of the actual time needed to hand weed each plot in the two over-all weedings. In 1964 records were kept of the first three harvests.

In the 1964 strawberry planting, the seedbed was prepared April 16 and planted April 17, variety Midway. Post-planting applications of herbicides were made 6 and 55 days after transplanting. Individual plots were 14 feet long and 4 feet wide of 7 plants each. Treatments were randomized in each of 6 blocks. Chemicals were applied in a 2 foot band over the row. An estimate of weed control was made just prior to the two hand weedings and at the end of the growing season. Records were kept of the actual time needed to hand weed each plot. An estimate of vigor of the strawberry plants making up the row was made at the end of the growing season.

Cultivation controlled the weeds between the rows. All estimates were on a 1 to 10 basis, 1 being most desirable and 10 least desirable.

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Results and Conclusion

The results are presented in Tables I and II. Estimates of weeds and actual time needed to weed the plot by hand were closely correlated. In the 1963 planting, two hand weedings of the check plot totaled 31.8 minutes and the best of the treatments 3.1 minutes. In the 1964 planting, two hand weedings of the check totaled 32.0 minutes, and the best of the treatments 5.5 minutes. All chemicals in both years significantly reduced the time needed for hand weeding.

Yields from the chemically treated plots from the 1963 planting made this year were not significantly better than that of the hand weeded check. Taking into consideration all records, the two best treatments were the combination of DCPA and simazine applied three times during the season and trifluralin applied three times during the season.

In the 1964 plantings, the most promising treatments were Hyvar X followed by diphenamid; DCPA, simazine combination followed by DCPA and simazine or by diphenamid; diphenamid followed by DCPA or by Dinoben G; or Dinoben followed by sesone. This estimate was based on weed control and the vigor of the plants in the row at the end of the growing season.

Table I. Weed Control, stand of plants and early yield of strawberries planted in 1963 under chemical herbicide treatments

Treatment	Active Rate per Acre lbs.	Application Day from Planting	Average per Plot: Weed Control* (1-10) 6/26	Weed Control* (1-10) 8/6	Hand Weeding Minutes 6/26	Hand Weeding Minutes 8/12	Hand Weeding Minutes Total	Stand of Plants	Yield 1964 Qts. Total
1 Hoed check	--	--	10.0	8.5	10.0	21.8	31.8	4.9	6.7
2 Trifluralin (three times)	2# & 2# & 2#	Inc - 1 + Post + 67 + 119	4.1	1.9	3.5	3.3	6.8	4.1	5.2
3 R-1607 (twice)	6# & 6#	Inc - 1 + Post + 119	2.1	6.1	2.1	12.0	14.1	2.5	4.3
4 Diphenamid	5#	Post + 3	2.0	7.0	1.8	13.4	15.2	4.4	7.6
5 Dinoben + Dinoben G (twice)	4# + 4# & 4#	Post + 3 + Post + 67 + 119	2.1	2.4	1.9	3.8	5.7	4.9	4.9
6 DCPA + Simazine (three times)	(10#+1#) (10#+1#) (10#+1#)	Post + 3 + 67 + 119	1.3	1.6	1.0	2.1	3.1	3.6	8.1
7 Trifluralin (three times)	4# & 2# & 2#	Post + 23 + Post + 67 + 119	3.1	2.6	2.3	6.1	8.4	4.5	8.0
8 EPTC + Simazine (twice)	(5#1#) (5#+1#)	Inc and Spray, Post + 23 + Post + 119	1.1	6.6	1.0	11.0	12.0	2.9	6.8
9 Sesone (three times)	3# & 3# & 3#	Post + 23 + 67 + 119	3.5	7.5	2.8	18.1	20.9	5.0	8.4
	Least significant difference 5%		.8	2.0	1.3	4.1	5.3	1.1	2.6
	Least significant difference 1%		1.1	2.7	1.7	5.5	7.1	1.4	3.4

*Weed Control 1-10: 1 perfect weed control
10 full weed growth

Table II. Weed Control and plant vigor of strawberries planted in 1964 under chemical herbicide treatment

Treatment	Active Rate per Acre lbs.	Days from Planting	Treatment	Active Rate per Acre lbs.	Days from Planting	Average per Plot: *Weed Control (1-10) 6/5	8/5	10/7	Hand Weeding Minutes 6/8	8/10	Total	*Vigor (1-10) 10/7
1 Hoed check	--	--	--	--	--	7.7	8.5	5.7	15.3	16.7	32.0	4.7
2 Diphenamid	6	+ 6	DCPA	10	+ 55	2.3	4.0	2.3	3.3	7.8	11.1	3.3
3 Diphenamid	6	+ 6	Dinoben	4	+ 55	1.8	3.2	2.5	3.8	7.0	10.8	3.5
4 DCPA + Simazine	10 + 1	+ 6	DCPA + Simazine	10 + 1	+ 55	2.0	1.5	2.3	2.8	3.0	5.8	4.7
5 DCPA + Simazine	10 + 1	+ 6	Diphenamid	6	+ 55	1.2	2.8	1.8	4.3	6.3	10.6	3.2
6 Dinoben	4	+ 6	Sesone	4	+ 55	2.7	5.2	3.8	5.3	10.3	15.6	4.3
7 Dinoben	4	+ 6	Diphenamid	6	+ 55	2.2	7.7	3.0	5.8	11.0	16.8	3.3
8 Hyvar X	1	+ 6	Hyvar X	1	+ 55	1.3	1.3	1.0	3.3	2.2	5.5	6.5
9 Hyvar X	1	+ 6	Diphenamid	6	+ 55	1.0	1.8	1.7	2.2	3.3	5.5	3.0
10 R-1607	6	+ 6	Diphenamid	6	+ 55	8.8	5.3	3.8	13.8	10.3	24.1	3.5
11 Sesone	4	+ 6	Sesone	4	+ 55	3.3	7.7	4.5	6.3	12.8	19.1	4.2
Least significant difference 5%						1.7	2.3	1.4	3.3	3.3	4.7	1.8
Least significant difference 1%						2.3	3.1	1.9	4.4	4.3	6.3	2.4

*Estimate 1-10: 1 most desirable
10 least desirable

HERBICIDE INVESTIGATIONS IN A FIRST YEAR STRAWBERRY PLANTING

Oscar E. Schubert[1]

The purpose of this experiment was to control weeds from the time a few runner plants were pegging-down until the end of the growing season.

METHODS AND MATERIALS

Midway and Surecrop strawberry plants were set April 17, 1964 on a heavy clay loam soil at the West Virginia University Horticulture Farm, Morgantown, West Virginia. Two rows of Midway were alternated with two rows of Surecrop throughout the planting. In addition, the plant roots of every other row were given a dip treatment of activated charcoal before setting. The plants were set 2 feet apart in rows 4 feet apart. The herbicide plots were 15 feet long and 8 feet wide to include two rows of each variety (with and without charcoal on roots).

Treatments 2,3,4,5,6,7 and 8 were applied to the variety Surecrop and treatments 9,10,11,12,13 and 14 were applied to Midway. Treatments were assigned at random within each of the five replications. The chemicals and rates used are given in Table 1.

All plots were weeded as necessary for weed control with a power cultivator and a hoe from the time of setting until June 25, the day before herbicides were applied.

RESULTS AND DISCUSSION

Runner Plants and Plant Stand: Between August 14 and 17, runner counts were made for each row in each plot to ascertain whether differences existed between charcoal dipped and undipped strawberry plants. Although small differences in numbers were noted in individual plots, the total runner plant count was 5155 from charcoal dipped mother plants and 5165 from untreated mother plants. Later observations of plant stand and vigor did not show any consistent differences related to charcoal treatment. Furthermore, since the average number of runner plants per mother plant for Surecrop was 8.0 compared with 7.8 for Midway all treatments are included in Table 1 without separation into variety or treatment of mother plant.

Eight to 10 runner plants per mother plant constitutes an ample number of runner plants by the middle of August for a well-spaced matted row. Six treatments 3,12,13,6,9 and 14 (diphenamid, EPTC, EPTC plus simazine, CP 31393, DCPA plus diphenamid and simazine) did not result in significantly fewer runner plants than the check (Table 1). Plots receiving 5 of these treatments

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Table 1. Herbicide treatments, runner plant numbers and average stand of strawberry plants set April 17, 1964 and treated June 26, 1964.

Treatment No.	Treatment Herbicide	Rate ai lb/A	Plant Injury 1=none 10=severe July 15	Average number of running plants per mother[g] plant August 17, 1964	Average stand[h] in matted row November 12, 1964
1	Check--Hoed as needed until September 15	----	1	11.0 a	88.6 a
3	Diphenamid 80 wp	6	1	9.2 ab	81.8 ac
13	EPTC 5 G + Simazine 80 wp	5 + 1	1	8.8 ac	85.8 ab
12	EPTC 5 G	5	1	8.9 ac	81.8 ac
11	Vernam[a] 6 ec + Simazine 80 wp	5 + 1	1.5	7.1 bc	56.8 bc
10	Vernam 6 ec	5	3	6.1 c	66.2 ac
8	Karsil[b] 2 ec + Simazine 80 wp	4 + 1	6	7.6 bc	78.8 ac
14	Simazine 80 wp	1	1	8.0 ac	80.0 ac
9	DCPA[c] 3 G + Diphenamid 1 G	6 + 2	1	8.0 ac	61.2 ac
6	CP 31393[d] 65 wp	8	3	8.1 ac	77.4 ac
4	CP 31675[d] 75 wp	3	1	7.6 bc	67.2 ac
5	G 14260[e] 50 wp	2	8	7.0 bc	68.8 ac
7	G 36393[e] 25 wp	2	9	6.5 bc	54.6 c
2	TH-052H[f]	5	3	6.9 bc	79.2 ac

[a] n,propyl-di-n-propylthiolcarbamate (Stauffer Chemical Company)
[b] N-(3,4-dichlorophenyl)-2-methylpentanamide (Niagara Chemical Div., FMC Corp.)
[c] formulation of DCPA and diphenamid (Miller Chemical and Fertilizer Corp.)
[d] from Monsanto Chemical Company
[e] from Geigy Agricultural Chemicals
[f] 4,5,7-trichlorobenzthiadiazole-2,1,3 (Thompson-Hayward Chemical Company)
[g] 70 mother plants in each treatment
[h] 100=full stand; 75=satisfactory stand

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.

Table 2. Weed control by October 3 (14 weeks after treatment) in herbicide treatments applied to strawberry plants on June 26 (10 weeks after setting).

No.	Treatment Herbicide	Rate ai lb/A	Grassy weeds in lbs. (air-dried) per treat. per (5plots)	Acre	Broadleaf weeds lbs. (air-dried) per treat.per (5plots)	Acre	Weed Control 10= None 100= All
1	Check--Hoed as needed until Sept. 15	---	3.1 c	225	7.0 a	508	84 a
3	Diphenamid 80 wp	6	2.5 c	182	1.7 a	123	94 a
13	EPTC 5 G + Simazine 80 wp	5 + 1	1.6 c	116	2.5 a	182	93 a
12	EPTC 5 G	5	5.6 ac	407	5.0 a	363	87 a
11	Vernam[a] 6 ec + Simazine 80 wp	5 + 1	6.3 ac	457	0.9 a	65	91 a
10	Vernam 6 ec	5	10.8 a	784	3.3 a	240	80 a
8	Karsil[b] 2 ec + Simazine 80 wp	4 + 1	2.8 c	203	0.3 a	22	96 a
14	Simazine 80 wp	1	8.3 ac	603	1.7 a	123	76 a
9	DCPA[c] 3 G + Diphenamid 1 G	6 + 2	6.8 ac	494	0.8 a	58	89 a
6	CP 31393[d] 65 wp	8	7.1 ac	515	0.2 a	15	92 a
4	CP 31675[d] 75 wp	3	2.9 c	211	4.3 a	312	89 a
5	G 14260[e] 50 wp	2	5.2 ac	378	8.1 a	588	86 a
7	G 36393[e] 25 wp	2	10.1 ab	733	2.6 a	189	84 a
2	TH-052H[f]	5	4.2 bc	305	1.6 a	116	89 a

[a] n,propyl-di-n-propylthiolcarbamate (Stauffer Chemical Company)
[b] N-(3,4-dichlorophenyl)-2-methylpentanamide (Niagara Chemical iv., FMC Corp.)
[c] formulation of DCPA and diphenamid (Miller Chemical and Fertilizer Corp.)
[d] from Monsanto Chemical Company
[e] from Geigy Agricultural Chemicals
[f] 4,5,7-trichlorobenzthiadiazole-2,1,3 (Thompson-Hayward Chemical Company)

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.

(DCPA plus diphenamid excepted) and Treatments 2 and 8 (TH-052H and Karsil plus simazine) made a satisfactory matted row or stand by November 12. It is possible that many of the runner plants rooted too late and formed too thick a row for optimum production.

Strawberry Plant Injury: The relative amount of injury following treatment is noted in Table 1. Six treatments (diphenamid, EPTC plus simazine, EPTC, simazine, DCPA plus diphenamid and CP 31675) did not result in any distinct injury that may be related to the treatment. Vernam plots showed a few leaves with yellowish-green chlorotic areas and small amounts of marginal necrosis, whereas, vernam plus simazine plots showed only traces of chlorosis and no marginal necrosis. CP 31393 and TH-052H plots showed small amounts of marginal necrosis. Karsil plus simazine treated plants had traces of chlorosis with large necrotic areas along margins and sometimes the entire leaflet was injured. G 14260 and G 36393 caused necrosis of many leaflets. On the basis of average stand in November it appears that injured plants of Treatments 2,4 and 8 (TH-052H, CP 31393 and karsil plus simazine) recovered well, but plants of Treatments 5,7 and 11 did not.

Weed Control: Tops of weeds in each plot were harvested between October 3 and 15 and weighed (in grams) after air drying. After statistical analysis the treatment totals were converted to pounds per 5 plots and also to pounds per acre (Table 2). Treatment 10 (vernam) was significantly poorer in grassy weed control than the following five treatments: 2--TH-052H; 3--diphenamid; 4--CP 31675; 8--karsil plus simazine; and 13--EPTC plus simazine. Treatment 7 (G 36393) was poorer than Treatments 3,4,8 and 13 above. Treatment 14 (simazine) was poorer than Treatment 13 (EPTC plus simazine) for control of grassy weeds. The differences between means were not significantly different for broadleaf weeds. The most common grassy weeds were goosegrass, crabgrass, yellow foxtail and barnyardgrass while ragweed, narrowleaf plantain and smartweed were the most common broadleaf weeds.

Visual weed control ratings are given in the last column of Table 2. All treatments gave satisfactory weed control throughout the period from June 26 to October 3 (14 weeks). Differences between treatments were not significant.

SUMMARY

Among 13 herbicidal treatments used in a first year strawberry planting at Morgantown, West Virginia, the best treatments for weed control with minimum plant injury from the period of June 26 to October 3 were diphenamid 6 lb/A ai and EPTC plus simazine 5 plus 1 lb/A ai.

ACKNOWLEDGEMENTS

The cooperation of the following companies in supplying the herbicides used in this experiment is gratefully acknowledged: Eli Lilly and Company, Geigy Agricultural Chemicals, Miller Chemical and Fertilizer Corporation, Monsanto Chemical Company, Niagara Chemical Division of Food Machinery and Chemical Corporation, Stauffer Chemical Company, and Thompson-Hayward Chemical Company.

CONTROL OF PERENNIAL GRASSES AND SEDGES IN LOWBUSH BLUEBERRIES WITH DICHLOBENIL

M.F. Trevett[1]

Introduction

The perennial grasses and sedges that abound in many lowbush blueberry[2] fields pose a problem in management. If commercial fertilizers are applied these herbaceous weeds respond more than lowbush blueberries. Competition for nutrients and water is increased and in addition the ensuring dense stand of culms and stems of the grasses and sedges makes harvesting of a high quality crop difficult. During raking many berries are sliced and mashed.

On the other hand, eradication of grasses and sedges is not desirable. Lowbush blueberries alone do not adequately protect the soil against erosion: grasses and sedges do, and therefore, seem to be essential components of the flora of blueberry fields.

The problem essentially is one of control, not eradication: Maintain grasses and sedges in fertilized fields at a level of productivity and vigor no greater than occurs in unfertilized fields.

Dalapon adequately controlled grassy weeds, but even at low rates caused formative injury in blueberries and reduced yields (1). Initial tests with Dichlobenil[3] indicated some selectivity in lowbush blueberries. The high volatility of Dichlobenil apparently precludes broadcast application (without incorporation) during summer and early fall since loss by vaporization is rapid above 32 degrees F. Thompson-Hayward (2) state: "The half life of a fine deposit on glass with an air flow of one-half liter per minute in an oven of a volume of 100 liters was two days at 40 degrees C. and 14 days at 25 degrees C."

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2/ *Vaccinium angustifolium* (Ait.), *V. Myrtilloides* (Michx.), *V. angustifolium var. laevifolium*, House, *V. angustifolium var. nigrum* (Wood) Dole, and their presumed hybrids.

3/ 2,6-dichlorobenzonitrile.

Procedure

Two granular formulations of Dichlobenil, 4G and 4FG, were applied in 1962 and in 1963 at various rates and at several dates, beginning in September and ending at freeze-up in either late November or early December, and in early spring of 1963 and 1964.

The fall treatments were applied broadcast in fields that were to be burned the following spring. The spring treatments were applied after burning in these same fields.

Control ratings were made in 1963 and in 1964 in the 1962 block, and in 1964 in the 1963 block.

Results

1962 Treatments: Table 1

Formulation:

In this test the G and FG formulations did not differ significantly. Compare treatment 7 with 8, and 9 with 10, Table 1.

Date of application:

Date of application was not significant. Five pounds Dichlobenil applied September 21, 1962, did not differ statistically in percent control from five pounds applied December 7, 1962, Table 1. The mean daily temperatures (F.) for the ten days following the September applications were: 46.0 - 44.5 - 48.0 - 50.0 - 45.0 - 55.0 - 54.5 - 50.0 - 48.0 - 55.5, Table 3. The mean daily temperatures for the ten days following the December application were: 42.5 - 38.5 - 35.5 - 39.5 - 32.0 - 26.5 - 16.0 - 10.0 - 8.5 - 9.0. Whether rainfall was a factor is debatable: .08 inches fell the 25th of September, .01 inch the 26th, 1.34 the 28th, and .98 the 29th. On December 6, 1962, 1.04 inches of rain fell, followed by .25 inches the 7th and .30 the 9th.

Rate of application:

Twenty pounds per acre of Dichlobenil is too high a rate. Not only was the stand of blueberries reduced but grasses and sedges were eradicated. Ten pounds per acre appeared to be on the threshold of too high a degree of control but apparently did not reduce blueberry stand. Five pounds gave adequate control and did not reduce the stand of blueberry stems.

Longevity of control:

Suppression of grasses and sedges extended over two growing seasons, Table 1. Ratings made August 13, 1964, gave approximately the same order and amount of control as obtained in 1963.

1963 Treatments: Table 2

Formulation:

As in 1962, in the 1963 block formulation was not a significant factor affecting control, Table 2.

Date of application:

Five pounds of Dichlobenil 4FG applied 27 September, 1963 gave significantly lower control than all other treatments, Table 2. In contrast, 5 pounds Dichlobenil 4G applied 21 September, 1962, gave control equal to all but one of the other rates, Table 1. Temperature differences for the two week period following application seems not to have been a significant factor, Table 3.

Whether rainfall affected control for the September dates is problematical. Within seven days after application in 1962, 1.44 inches of rain fell; in 1963, 3.73 inches.

Weed species may be of some importance in determining percent control. In the 1962 block, Oryzopsis, Panicum and Danthonia predominated; in the 1963 block, Carex made up ninety percent of the weed population. However, except for 27 September, other dates of application in 1963 did not significantly affect control, Table 2. The extremely high variation as indicated by the L.S.D. - 22.48 - no doubt prevented closer assessment of the effect of date.

Rate of application:

In 1963, 1, 3, and 5 pounds of Dichlobenil per acre were applied. One and 3 pounds gave inadequate control at all dates, and except for treatment 26, Table 2, ratings for these rates were not included in Table 2.

Longevity of control:

Grass and sedge control in the 1963 block did not persist as long as in the 1962 block. By late September, 1964, control in the 1963 block had dropped to about one-half of that observed 19 June, 1964, Table 2.

Conclusion

For late fall application, 5 to 10 pounds per acre of Dichlobenil in either the 4G or 4FG formulation are required to adequately control perennial grasses and sedges in lowbush blueberry fields in Eastern Maine.

Literature Cited

(1) Trevett, M.F. 1958. Grass Control in Lowbush Blueberry Fields with Dalapon. Proceedings of the Twelfth Annual Meeting of the Northeastern Weed Control Conference. pp. 374-382.

(2) Anonymous. March, 1962. Technical Information Bulletin, Casoron, Vol. 2. Thompson-Hayward Chemical Company, Kansas City, Missouri.

Table 1. Percent "Grass"[1/] Control with Dichlobenil, 1962 Block.

Treatment number, acre rate of active ingredient, and date of application	Ratings made 3 July, 1963		Ratings made 13 August, 196	
	Means: arcsine transformation	Means: Percent not transformed	Means: arcsine transformation	Means: Percent not transformed
4. 20# Dichlobenil 4G Sept. 21 '62	78.93a[2/]	95.0	69.82a[2/]	87.3
7. 10# Dichlobenil 4G April 23 '63	64.86ab	78.7	64.84ab	80.0
10. 10# Dichlobenil 4FG May 15 '63	63.98ab	77.5	60.35abc	75.0
12. 10# Dichlobenil 4G Dec. 7 '62	63.66ab	77.5	70.05a	87.5
3. 10# Dichlobenil 4G Sept. 21 '62	62.04ab	77.5	56.44abc	68.7
8. 10# Dichlobenil 4FG April 23 '63	61.22ab	75.0	58.05abc	71.2
9. 10# Dichlobenil 4G May 15 '63	60.82ab	75.0	48.89abc	56.2
6. 10# Dichlobenil 4G Oct. 19 '62	54.22abc	65.0	65.56ab	82.0
2. 5# Dichlobenil 4G Sept. 21 '62	42.03 bc	45.0	37.50 c	43.7
11. 5# Dichlobenil 4G Dec. 7 '62	38.88 bc	40.0	42.11 bc	46.2
5. 5# Dichlobenil 4G Oct. 19 '62	38.80 c	40.0	47.36abc	55.0
L.S.D. 5%	22.6		20.18	

1/ Includes: Danthonia Spicata L., Oryzopsis Canadensis Man., Panicum Subvillosum Ashe.

2/ Duncan's Multiple Range Test.

Table 2. Percent "Grass"[1/] Control with Dichlobenil, 1963. Rated 19 June, '64.

Treatment number, acre rate of active ingredient date of application	Means: arcsine transformation	Means: Percent not transformed
27. 5# Dichlobenil 4FG Nov. 28 '63	39.50a[2/]	42.5
24. 5# Dichlobenil 4FG Nov. 15 '63	33.75ab	32.5
21. 5# Dichlobenil 4G Nov. 11 '63	32.29ab	35.0
18. 5# Dichlobenil 4G Oct. 16 '63	21.06ab	22.5
28. 5# Dichlobenil 4FG May 7 '64	14.94ab	12.5
26. 3# Dichlobenil 4FG Nov. 28 '63	9.22 b	5.0
15. 5# Dichlobenil 4FG Sept. 27 '63	2.49 c	0.8
L.S.D. 5%	22.48	

1/ Includes: *Carex Pennsylvanicum Lam.*; *Danthonia Spicata* L.; *Oryzopsis Canadensis* Man.

2/ Duncan's Multiple Range Test.

Table 3. Daily Temperature (°F.), Jonesboro, Maine. Means for 1953-1962, and 1962 and 1963.

Month & Day	Mean °F. 1953-1962	Daily Mean °F. 1962	Daily Mean °F. 1963	Month & Day	Mean °F. 1953-1962	Daily Mean °F. 1962	Daily Mean °F. 1963	Month & Day	Mean °F. 1953-1962	Daily Mean °F. 1962	Daily Mean °F. 1963
Sept.				Oct.				Nov.			
1	63.2	65.5	60.0	1	56.2	56.5	43.0	1	47.3	49.5	39.5
2	63.1	60.5	60.5	2	51.6	52.0	44.0	2	44.1	42.5	42.0
3	60.4	60.0	59.5	3	52.3	53.5	54.5	3	42.7	39.0	46.5
4	61.1	59.0	63.5	4	51.3	60.0	56.0	4	42.0	41.0	35.0
5	61.7	60.0	49.5	5	51.7	58.5	41.0	5	43.9	44.5	39.0
6	61.0	56.0	49.0	6	47.3	42.5	48.5	6	43.1	36.5	46.7
7	59.9	47.5	50.0	7	47.0	50.0	54.5	7	41.6	35.0	49.5
8	59.3	54.5	57.5	8	49.6	52.0	64.3	8	40.2	35.5	52.5
9	57.5	60.5	49.0	9	51.7	50.0	47.3	9	39.2	44.0	54.0
10	57.1	64.5	59.5	10	50.2	45.5	34.5	10	38.2	44.0	40.5
11	59.2	58.5	53.0	11	51.4	45.0	39.0	11	36.0	45.5	40.5
12	58.9	61.0	56.5	12	46.9	46.5	50.0	12	35.7	39.5	40.5
13	56.8	58.0	51.5	13	45.5	48.0	40.0	13	35.6	28.5	39.5
14	54.8	59.0	44.0	14	47.2	40.5	44.0	14	36.0	29.5	31.0
15	55.3	62.5	48.5	15	46.2	42.0	53.5	15	40.2	31.5	31.0
16	55.0	56.5	52.5	16	47.2	50.5	57.5	16	39.2	31.0	32.5
17	53.0	51.5	64.0	17	49.3	50.5	61.0	17	42.0	29.5	32.5
18	53.8	56.0	60.5	18	49.4	45.5	48.5	18	40.2	31.5	39.0
19	52.4	58.5	62.0	19	47.3	48.0	53.0	19	35.4	26.5	42.5
20	54.4	54.0	53.5	20	46.7	51.0	64.5	20	35.1	23.0	33.5
21	54.2	46.0	52.5	21	43.7	49.0	59.5	21	34.7	27.5	36.5
22	52.8	44.5	43.0	22	41.8	41.5	42.5	22	39.4	44.0	41.0
23	54.8	48.0	38.5	23	41.0	41.5	41.0	23	34.6	40.0	45.5
24	54.7	50.0	46.5	24	48.5	38.5	51.0	24	35.4	29.5	45.5
25	53.7	45.0	52.0	25	46.1	36.5	61.0	25	37.0	25.5	32.0
26	53.6	55.0	56.0	26	41.6	38.5	58.0	26	32.7	21.0	27.5
27	53.6	54.5	56.0	27	41.3	36.0	61.5	27	33.9	29.0	34.5
28	52.9	50.0	55.0	28	41.6	36.0	63.5	28	37.6	33.5	33.0
29	52.0	48.0	44.0	29	41.8	46.0	46.0	29	37.0	39.5	24.5
30	53.9	55.5	50.0	30	43.9	32.5	37.0	30	33.9	38.0	48.5
				31	43.1	35.0	35.0				

WEED CONTROL AS A FACTOR IN SOIL MOISTURE CONSERVATION UNDER APPLE TREES

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The use of herbicides for the control of weeds, grasses and broadleaf plants in apple orchards is rapidly becoming a standard practice in commercial orchards to aid in mouse control, to reduce fire hazard and to reduce competition for moisture and nutrients. The question here is how much soil moisture is conserved by the use of chemical weed control under apple trees grown under the sod-mulch system of culture? Soil moisture is rarely a limiting factor under mature apple trees in Massachusetts grown under the sod-mulch system of culture (1). However, in the case of young trees with limited root systems it would be expected that soil moisture conditions might be critical in some seasons. The purpose of this study was to determine the effect of weed control on soil moisture levels in young apple orchards in the area of maximum root concentrations.

METHODS AND MATERIALS

Eighteen 6-year old apple trees on Malling VII rootstock in the University orchard were selected for the study. On May 6, dalapon, an herbicide which controls grasses, was applied at the rate of 8.5 lb active ingredient per acre to an area having a radius of 6 feet from the base of alternate trees. It was necessary to re-treat some of the plots with amazine at the rate of 7 lb per acre of the commercial material in July because of some regrowth of grasses. The elimination of grass species created a favorable competitive environment for the establishment of broadleaf weeds, especially sorrel. An estimation of weed control was rated at 85 per cent on August 16, 1963; the species present were broadleaf weeds, particularly sorrels.

Three moisture sensing stations were used under each tree. These were spaced 120° apart at a distance of 3 feet of the tree trunks. At each sensing station concentric gypsum soil moisture sensing units (2) were placed at 6 and 12 inch soil depths. Due to variability of soil moisture level under individual trees and among trees as previously described by the authors (3) this was considered the minimum of sensing units needed to obtain reliable results. Resistance readings were taken under each tree with an A.C. bridge and these values were converted to per cent of available soil moisture as described in a previous paper (3). The available moisture percentages were further converted to inches of water in the top 12 inches of soil and are so reported.

RESULTS

Rainfall data are the official meterological observations of the Massachusetts Agricultural Experiment Station which is located nearby and are shown in figure 1.

Total rainfall for the 4 months, May through August, was 67 per cent of normal (Figure 1). More important than the total rainfall, however, was its effectiveness for only two rainstorms of 1 inch or more occurred during the period which only slightly recharged the soil as shown in figure 1. The majority of precipitation was less than 0.35 inches and had little "effective" value. The soil moisture depletion graph of figure 1 shows that these small amounts of rainfall were effective only in maintaining the soil moisture level at the 6 inch depth slightly above that at the 12 inch depth.

The differences in the evapo-transpiration under the trees with non-mowed grass as compared with those plots with the chemical weed control is reflected in the divergence of the graph of soil moisture depletion in figure 1. At the beginning of the experiment the soil moisture was at field capacity or 1.56 inches of water per foot of soil. On July 29 the average soil moisture value of the 6 and 12 inch depths under the trees with the grass competition eliminated by the weed control was 64 per cent of available moisture or 1.03 inches of water per foot of soil while the non-mowed plots had 19 per cent available moisture or 0.20 inches of water per foot of soil. By August 30, the moisture under the weed control plots were depleted to 43 per cent available moisture or 0.67 inches of water per foot of soil as compared to 10 per cent available moisture or 0.16 inches per foot of soil under the non-mowed plots.

DISCUSSION

In years of limited effective rainfall the elimination of grass competition under fruit trees may be beneficial. Ample research data is available which indicate the value of frequent mowing under fruit trees. The data indicate that comparable results can be obtained by chemical weed control.

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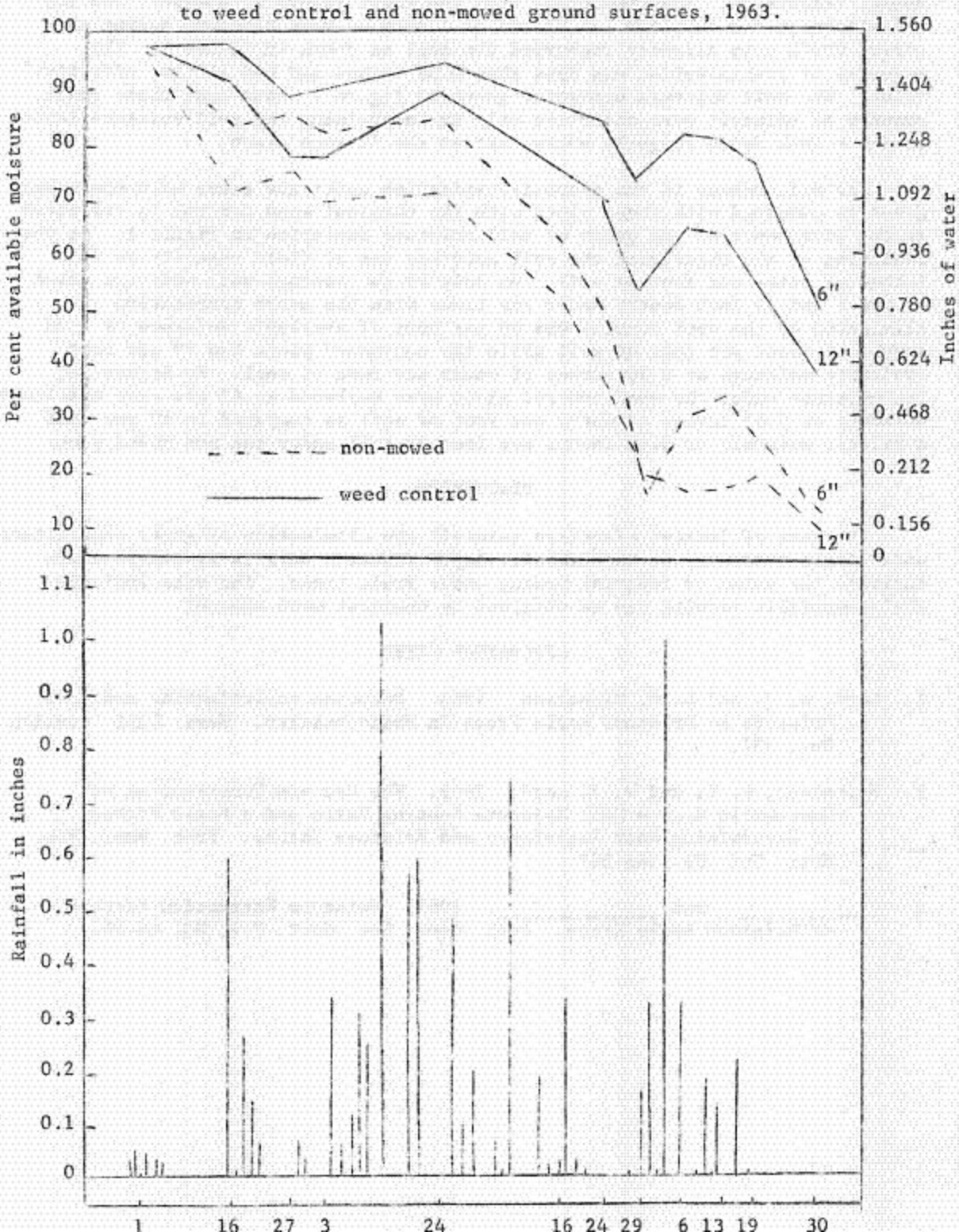
Figure 1. Rainfall and Soil Moisture conditions, expressed as inches of available water, under 6-year old apple trees as related to weed control and non-mowed ground surfaces, 1963.



Weeds, Grass, and Poison Ivy Control Around Young and Old Apple Trees

By C. A. Langer[1]

Introduction

Poison ivy is one of the most undesirable pests in an orchard. It creates a definite health hazard to the orchard workers from pruning through harvest. Sod and weeds impede growth of new orchards and require hand mowing to preserve soil moisture. Uncontrolled growth of sod and weeds around trees makes an ideal habitat for mice and other pests.

This research was carried on during the past two years in order to evaluate several materials and combinations of materials for their efficiency in controlling weeds, especially grasses and poison ivy. Also, the development of phytotoxic symptoms on young trees, or possible stimulation resulting from any of the chemicals applied purely for weed control was to be recorded.

Procedure

In 1963 research plots were established in six young orchards to evaluate weed control around the trees. Plots were established in two mature orchards where poison ivy was a particular problem. In 1964 these same plots were continued, augmented by two new young tree plots and one mature tree plot infested with poison ivy. Trees in three of the eight plots in young orchards were on malling VII root stocks. Trees in the other five plots were on standard root stocks. Within the older orchard plots, were all large, productive 25-30 year old specimens of McIntosh.

The herbicides used were Amino-Trizole, Simazine, Dalapon, Paraquat, Karmex, Amizine WP, Amizine (63-102), and combinations of Simazine and Dalapon, Simazine and Paraquat, Karmex and Paraquat. Materials were applied to the area immediately around young trees when the grass was 3 to 10 inches tall and to the area under mature trees at the time of blossoming. If poison ivy was growing up the tree, the ivy also was covered to a height of seven feet above the ground with the herbicide.

All spray was applied at the rate of 100 gallons of mix/acre. The applicator was a knapsack sprayer with an agitator and pumps to maintain constant pressure and dispersion of the materials. The amount to apply per tree was determined as follows. The discharge of the sprayer under constant pressure was measured for 60 seconds. From this figure the number of seconds to spray a given number of square feet was calculated. For example, if spraying an eight foot circle around a young tree, 40 square feet would be treated. Accordingly, 11 trees would constitute 1/100 acre. If the discharge of the

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sprayer at a constant pressure is determined to be 344cc each 20 seconds (344cc = 1/11 gallon) then the eight foot circle sprayed for 20 seconds will deliver the proper dose. The mature trees had a diameter of 23 to 24 feet limb spread, an area equal to 1/100 of an acre. One gallon of spray was therefore used to cover the area under each mature tree. The spray concentrations were identical to those used for the young trees.

Care was taken when spraying around the young trees to avoid contact with the trunks. Areas around the trees were treated only once during the year. Trees were inspected two weeks after herbicide application and again in June, July, August and October. Observations of tree growth were made in October, but no precise measurements were made, even though there was an indication of some increased growth in comparison with check trees. Six to eleven young trees were treated with each chemical or chemical combination in each of the six orchards in 1963 and in each of the eight orchards in 1964. One to three mature trees replicated three times were treated in each of three orchards with Amizine, Amitrol-T, Paraquat and Simazine, and Paraquat plus Karmex. The same procedures for inspection were carried out as followed with the young trees. Materials were weighed for 1/100 acre plots mixed with one measured gallon of water in the field. The dosage of liquid concentrates was calculated in cc/1/100 acre. These liquids also were measured and weighed in the field.

Results and Discussion

The control of weeds and grass around young trees shown in Table 1 is clear. It should be mentioned, however, that check plots show commercial acceptable control of broadleaf weeds. Apparently, the grass made such a tight sod that the broadleaf weed population was held to commercial control. However, the grass control in the same check trees was zero.

Differences were noted in this trial in the behavior of certain chemicals. Amitrol-T, Dalapon, Amizine, Simazine were much slower to react than Paraquat. Amizine and other combinations, including Simazine, were more consistent in suppressing the broadleaf weeds. In the second part of Table 1 on grass control, it is evident that Paraquat killed weeds more rapidly and persisted as well as any of the materials used. Amitrol-T, Amizine and Dalapon were found to be superior. They were slower to react than Paraquat, but suppressed weeds throughout the growing season.

One observation not evident in Table 1 is that several Amizine treated trees in each plot on each farm were left the second year without treatment. There was no new growth around these trees at treatment time. The plots were left untreated to determine if they would suppress new weed and grass growth for an additional year without treatment. Broadleaf and grass weeds were held in check through August, but in September and October late germinating species of grasses and weeds started to grow. Seeds, undoubtedly, blew in from the rest of the orchard floor.

Table 2 shows the poison ivy control resulting from the several herbicides used. Amitrol-T and Amizine gave outstanding results in these trials. Paraquat was effective early in the season, but did not persist. About 30 percent of the ivy treated with Paraquat survived. Several additional treat-

Table 1

Poison Ivy, Weeds, and Grass Control
Around Mature Apple Trees

Averages of the 8 Orchards for 1963-64

No.	Materials and Formulation	Rate Amt/Acre	Inspection Dates 5/29	6/16	7/15	8/17	10/8
		Broadleaf Weed Control*					
1	Check	- - - -	7.5	7.5	7.5	7.5	7.5
2	Amitrol-T	1 gal.	8	9	7	5	3
3	Amizine	7 lbs.	8	9	9½	9½	9½
4	Dalapon	7½ lbs.	7	7	7	5	2
5	Dalapon & Simazine	7½ lbs. + 5 lbs.	7	9.5	9½	9	9
6	Paraquat & Simazine	½ gal. + 5 lbs.	10	10	9½	9	9
7	Paraquat	½ gal.	10	10	8	6	4
		Grass Control*					
1	Check	- - - -	0	0	0	0	0
2	Amitrol-T	1 gal.	8	10	10	10	8.5
3	Amizine	7 lbs.	8	10	10	10	9.5
4	Dalapon	7½ lbs.	7.5	9	10	10	8.5
5	Dalapon & Simazine	7½ lbs. + 5 lbs.	7.5	9	10	10	8.5
6	Paraquat & Simazine	½ gal. + 5 lbs.	10	10	10	10	9.5
7	Paraquat	½ gal.	10	10	10	10	8

* 0 = No control; 10 = near perfect; 7.5 = commercial weed control

Results and Discussions (cont.)

ments with Paraquat will undoubtedly kill the ivy. Amizine in most instances where the ivy was vigorous and thick took two years before the ivy was noticeably weakened. Only 5 to 10 percent remained alive and this very weak. The weed and grass control under these same trees treated for ivy was excellent. Amitrol-T was the only chemical that failed to hold broadleaf weeds late in the season.

Conclusion

1. It is possible to control grass and weeds around young trees with a number of materials.

2. It has been shown that no damage to young trees has occurred during the past two years. This also includes trees on malling root stocks that have a limited root system.

Table 2

Poison Ivy, Weeds, and Grass Control
Around Mature Apple Trees

Averages of the 3 Orchards for 1963-64

No.	Materials and Formulations	Rate Amt/Acre[1]	Inspection Dates 5/29	6/16	7/15	8/17	10/8
	Poison Ivy Control*						
1	Check	0	0	0	0	0	0
2	Paraquat	½ gal.	10	8	7	7	7
3	Paraquat & Karmex	½ gal. + 4 lbs.	10	8	7	7	7
4	Paraquat & Simazine	½ gal. + 5 lbs.	10	10	9	8	8
5	Amitrol-T	½ gal.	9	10	10	9.5	9.5
6	Amizine WP	7 lbs.	9	10	10	10	9.5
	Broadleaf Weeds and Grass Control*						
1	Check	- - -	0	0	0	0	0
2	Paraquat	½ gal.	10	10	10	9	9
3	Paraquat & Karmex	½ gal. + 4 lbs.	10	10	10	9	9
4	Paraquat & Simazine	½ gal. + 5 lbs.	10	10	10	9½	9
5	Amitrol-T	1 gal.	9	10	9	7½	7½
6	Amizine WP	7 lbs.	9	10	10	10	10

* 0 = No control; 10 = Near Perfect; 7.5 Commercial weed control
1 Amounts are actual chemicals per acre

Conclusion (cont.)

3. Chemical weed control is cheaper than mulching or frequent mowing that otherwise would be required to achieve comparable control.

4. Chemical weed control reduces the possibilities of rodent damage, especially that of mice.

5. Increased action from fertilizers results from lack of competition from grass and weeds.

6. Less commercial fertilizer may be needed per tree if chemical weed control is practiced, but this must be tested.

7. Poison ivy can be controlled and after several years eliminated.

8. Time and experience will be necessary to evaluate fully chemical weed control in fruit orchards.

EVALUATION OF HERBICIDES FOR APPLE AND PEACH TREES

Frank N. Hewetson[1]

The use of chemicals to control weeds around fruit trees has now become an established practice in most of the important fruit growing areas of the United States. As the use of these chemicals becomes greater, so do the problems. A herbicide which is satisfactory today may be entirely inadequate by tomorrow. Weed populations change during the season, from year to year, and from area to area. Therefore it is necessary to evaluate new chemicals and combinations continuously so that there will be available to the fruit growing industry the best and safest material for every situation as it arises.

METHODS AND PROCEDURES

The materials in these experiments were applied on single tree plots and also on a commercial scale, using multiple row plots. The treatments were randomized in each of three blocks and were applied with a Spraying Systems double swivel type nozzle gun with two OCO2 tips as a directed spray around the base of the tree, covering a 6 x 6 ft. area. The spray was applied on each side for a given time at a given pressure so as to be sure that exactly the right amount of material was applied per tree area. The large scale herbicide applications were made with a 5 ft. boom fastened to the side of a tractor and held at a constant height by a skid at the end of the boom. This boom was fitted with two 80015 TeeJet nozzles plus one OCO2 type TeeJet tip at the end of the boom. This made it possible to spray close to the tree without danger of hitting the tree trunk with the end of the boom. The spray was turned on and off at each tree by means of a quick shut-off valve fastened on the tractor fender. The operator, by driving at a constant pre-determined speed was able to apply herbicides in an orchard very effectively and accurately, and cover an almost perfect 6 ft. square with a minimum of effort.

Previous work has indicated the desirability of combining a number of different herbicides when complete control of vegetation around fruit trees is required for the entire season. This is especially true when both broadleaved and grass types of weeds are present, which is nearly always the case in orchards. As a further recommendation for the use of a mixture of herbicides is the findings of previous work at Arendtsville, showing that with some combinations there appears to be a synergic as well as an additive effect when more than one herbicide is used in a mixture.

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RESULTS AND DISCUSSION

In Tables I and II, Amitrol T, dalapon and paraquat were used as a base material, to which were added simazine, prometryne, diuron, diphenamid or dichlobenil. Although Amitrol T was used above the legal limits in this work, no injurious effect was observed in any of the treatments.

The results of the various treatments around the apple trees indicate a very definite benefit from the use of three herbicides in the mixture, as shown in treatments 3 and 7, and to a lesser extent in treatment 5. Dalapon by itself (Tr. 13A) was relatively ineffective because of the subsequent growth of broadleaved weeds in these plots, though the control was greatly improved with the addition of simazine in treatment 14A. The great value of using dalapon as an orchard herbicide is its ability to control grasses, but it must be used with a good broadleaf herbicide in order to give adequate weed control. Paraquat was relatively effective at the time the ratings were made, but later in the season this chemical by itself, in spite of the two applications, permitted considerable weed growth. The addition of simazine, however, held down the weed growth in the paraquat plots considerably. The results in the peach experiment were complicated by the presence of poison ivy, which was not too well controlled by having to apply these sprays just before bloom. The initial composition of the weed population has a great deal to do with the effectiveness of chemical weed control, and is well illustrated in comparing the results of the apple and peach experiments.

A third experiment was conducted on a commercial scale in which Amitrol T at 1.5 lbs. AI/A plus simazine at 3.2 lbs. AI/A mixture was compared with these same materials to which dalapon at 4.0 lbs. AI/A had been added. While the Amitrol T plus simazine mixture gave what would generally be considered commercially satisfactory control, the addition of dalapon gave almost complete weed control throughout the entire season and justified the addition of this herbicide to the mixture.

SUMMARY AND CONCLUSION

The results from these experiments substantiate the previous findings that, as of today, a good orchard herbicide spray mixture must contain several types of herbicide in order to do a complete job of controlling the vegetation around fruit trees for the entire season. To date, the Amitrol T, simazine and dalapon or the Amitrol T, diuron and dalapon mixtures appear to be very promising mixtures.

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Table I

HERBICIDE EXPERIMENTS - 1964

APPLE

TREATMENTS

Treatment No.	Material	Rates of Application AI/A	Weed Control (0-10)* 8/17/64
1.	Amitrol T	3 lbs.	1.5
2.	Amitrol T Simazine	3 lbs. 3.2 lbs.	4.0
3.	Amitrol T Simazine Dalapon	3 lbs. 3.2 lbs. 6.8 lbs.	8.6
4.	Amitrol T Prometryne	3 lbs. 3.2 lbs.	7.0
5.	Amitrol T Prometryne Dalapon	3 lbs. 3.2 lbs. 6.8 lbs.	6.6
6.	Amitrol T Diuron	3 lbs. 3.2 lbs.	7.8
7.	Amitrol T Diuron Dalapon	3 lbs. 3.2 lbs. 6.8 lbs.	8.7
8.	Amitrol T Dichlobenil	3 lbs. 2 lbs.	1.5
9.	Amitrol T Diphenamid	3 lbs. 8 lbs.	5.0
10.	Paraquat & Joy (1Cup)	1 lb.	4.8
11.	Paraquat Simazine	1 lb. 3.2 lbs.	5.5
12.	SD 7961	1.6 lbs.	0
13A.	Dalapon	6.8 lbs.	0.2
14A.	Dalapon Simazine	6.8 lbs. 3.2 lbs.	4.3

*Weed Control 0-10: 0= no control, 10= perfect control

Dates of Application: May 4 - 6/64 Initial
June 23/64 Supplementary
Tr. 10,11 Paraquat - 1 lb. AI/A

Table II

HERBICIDE EXPERIMENTS - 1964

PEACH

TREATMENTS

Treatment No.	Material	Rates of Application AI/A	Weed Control (0-10)* 8/17/64
1.	Amitrol T	3.0 lbs.	3.2
2.	Amitrol T Simazine	3.0 lbs. 3.2 lbs.	8.0
3.	Amitrol T Simazine Dalapon	3.0 lbs. 3.2 lbs. 2.6 lbs.	4.5
4.	Amitrol T Prometryne	3.0 lbs. 3.2 lbs.	5.1
5.	Amitrol T Prometryne Dalapon	3.0 lbs. 3.2 lbs. 2.6 lbs.	4.8
6.	Amitrol T Diuron	3.0 lbs. 3.2 lbs.	4.8
7.	Amitrol T Diuron	3.0 lbs. 3.2 lbs.	6.3
8.	Amitrol T Dichlobenil	3.0 lbs. 2.0 lbs.	1.0
9.	Amitrol T Diphenamid	3.0 lbs. 8.0 lbs.	3.0
10.	Paraquat	1.0 lbs.	8.7
11.	Paraquat Simazine	1.0 lbs. 3.2 lbs.	7.7
13.	Dalapon	2.6 lbs.	0.1
14.	Dalapon Simazine	2.6 lbs. 3.2 lbs.	6.5
15.	Dalapon Prometryne	2.6 lbs. 2.0 lbs.	4.0
16.	Dalapon Diphenamid	2.6 lbs. 8.0 lbs.	1.5
17.	Dalapon Dichlobenil	2.6 lbs. 2.0 lbs.	0.5
18.	Dalapon Diuron	2.6 lbs. 3.2 lbs.	4.8

*Weed Control 0-10: 0= No control, 10= Perfect c
tro

Dates of Application : May 4-5/64 Initial
June 23/64 Supplementary
Tr. 10, 11 Para
1 lb. AI/A
Tr. 13,14,15,16
18 -Dalapon 2.6
/A.

HERBICIDE EVALUATION ON APPLES AND PEACHES

William V. Welker, Jr.[1/]

During the summer of 1963 we evaluated a number of herbicides for possible use in peach and apple orchards. We continued this study in 1964. For the screening experiment we used a randomized complete block design with 3 replications. Each plot consisted of one peach and one apple tree, both planted on April 5, 1963 in sandy loam. We sprayed the herbicides directed to the base of the trees. On June 17, 1963 and May 26, 1964 we applied the pre-emergence herbicides. On July 12, 1963 and June 22, 1964 we applied the post-emergence herbicides. The same herbicides were applied to the same plots in 1963 and 1964. One week after applying the pre-emergence herbicides, we applied an inch of irrigation water.

The major weeds were: lambsquarters (*Chenopodium album* L.); pigweed (*Amaranthus retroflexus* L.); crabgrass (*Digitaria sanguinalis* (L.) Scop.); and goosegrass (*Eleusine indica* (L.) Gaertn.).

The treatments were as follows:

Pre-emergence

3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	(linuron)	4 & 8 lb/A
3-amino-2,5-dichlorobenzoic acid	(amiben)	4 & 8 lb/A
N,*N*-dimethyl-2,2-diphenylacetamide	(diphenamid)	4 & 8 lb/A
2,6-dichlorobenzonitrile	(dichlobenil)	6 & 12 lb/A
3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea	(norea)	3 & 6 lb/A
5-bromo-3-isopropyl-6-methyl uracil	(isocil)	5 & 10 lb/A
alpha,alpha,alpha-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine	(trifluralin)	4 & 8 lb/A
2,3,5,6-tetrachloroterephthalic acid	(DCPA)	16 lb/A
ethyl *N*,*N*-dipropylthiolcarbamate	(EPTC)	4 & 8 lb/A

Post-emergence

methyl 3,4-dichlorocarbanilate	(swep)	3 & 6 lb/A
1,1'-dimethyl-4,4'-bipyridinium salt	(paraquat)	1 & 2 lb/A

[1/] Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the

Satisfactory weed control, with respect to initial and length of activity, resulted with all herbicides except norea, EPTC, and trifluralin in 1963. We incorporated neither EPTC nor trifluralin in 1963. Moderate to good control resulted with norea in 1964. Control with EPTC and trifluralin, when incorporated in 1964, proved excellent. With the exception of isocil, none of the herbicides caused visible injury. Apple trees were killed by both rates of isocil the first year of application. Peaches were severely injured; however, they were not killed even with the high rate applied for two years. Peach trees, allowed to establish for a year before applying 5 lb/A of isocil, showed no injury symptoms after two years of treatment.

From this experiment it would appear that a number of herbicides, found excellent for weed control, deserve more detailed investigation in apple and peach orchards.

POST-TRANSPLANT APPLICATIONS OF HERBICIDES IN PETUNIAS

Chiko Haramaki and Samuel Atmore[1]

The major annual flower which is used in this country as a bedding plant is the petunia. Pre-transplant herbicide treatments have been successfully used in these plantings. In many other transplanted crops, safe and effective weed control has been obtained by the application of a pre-emergent herbicide shortly after transplanting. In past studies we have obtained good weed control with the use of post-transplant applications of granular herbicides in annual flower crops. The objectives of this experiment were to study the effectiveness of liquid and granular applications of herbicides on weed control and their effect on recently transplanted petunias.

Methods

The land was plowed in the fall, and then disced and meekered several times during the spring prior to planting. The Red Satin petunia seeds were sown on May 2, 1964 in the greenhouse and transplanted to flats on May 21. On July 6 they were planted in the field and an inch of water was applied.

The spray treatments were applied on July 20 and the granular herbicides were applied on July 22 to the petunia plantings, which had been previously clean cultivated by rototilling and hand hoeing. The soil temperature at one and six inches below the soil surface was 94° F and 80° F respectively. The air temperature was 82° F in the shade and the soil moisture was near field capacity at the time of spraying.

Seven herbicides were sprayed and seven herbicides were applied in the granular form. Each herbicide was applied at three concentrations plus a check and replicated three times. In this experiment there were 168 plots, each of which had 51 square feet.

Results and Discussion

On August 13 the plots were examined for weed prevalence and injury to the petunias. The effects of the sprayed treatments are tabulated in Table 1 and that of the granular herbicides in Table 2.

In the sprayed treatments, good weed control was observed in the following treatments: dacthal at 16 pounds per acre, dichlobenil at 4 and 8 pounds per acre, diphenamid at 8 pounds per acre, diuron at 1, 2 and 4 pounds per acre, tenoran at 2, 4 and 8 pounds per acre, TH-052H at 2 and 8 pounds per acre, and trifluralin at 2, 4 and 8 pounds per acre. Injury

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Table 1. Effect of post-transplant herbicide spray applications on weed prevalence and on petunias, 1964

Herbicide	Active Rate	Weed Prevalence	Plant Injury**
Dacthal, 50 WP	0	2.67	0.29
	4 #/A	1.67	0.54
	8 #/A	1.33	0.67
	16 #/A	1.00	0.92
Dichlobenil, 50 WP	0	1.33	0.04
	2 #/A	1.67	0.21
	4 #/A	0.67	0.38
	8 #/A	0.67	0.25
Diphenamid, 50 WP	0	1.67	0.29
	2 #/A	1.33	0.00
	4 #/A	1.33	0.13
	8 #/A	0.67	0.08
Diuron, 80 WP	0	1.33	0.04
	1 #/A	0.00	2.38
	2 #/A	0.00	3.42
	4 #/A	0.00	4.52
Tenoran, 50 WP	0	1.67	0.04
	2 #/A	0.33	1.42
	4 #/A	0.00	2.08
	8 #/A	0.00	1.96
TH-052H, 50 WP	0	1.67	0.13
	2 #/A	1.00	0.16
	4 #/A	1.33	0.29
	8 #/A	0.67	0.63
Trifluralin, 4 EC	0	1.67	0.08
	2 #/A	0.33	0.63
	4 #/A	0.33	0.29
	8 #/A	0.00	0.54

* 0 - No weeds, 10 - 100% weed coverage
** 0 - No injury, 5 - dead

Table 2. Effect of post-transplant applications of granular herbicides on weed prevalence and on petunias, 1964

Herbicide	Active Rate	Weed Prevalence*	Plant Injury**
CIPC 5 G	0	2.67	0.25
	2 #/A	2.00	0.25
	4 #/A	2.33	0.54
	8 #/A	1.67	0.21
Dichlobenil, 4 G	0	3.00	0.42
	2 #/A	2.67	0.43
	4 #/A	1.00	0.83
	8 #/A	1.00	0.33
Diphenamid, 5 G	0	2.67	0.38
	2 #/A	2.00	0.08
	4 #/A	2.67	0.46
	8 #/A	0.67	0.43
Diuron, 2 G	0	2.00	0.46
	1 #/A	3.00	0.26
	2 #/A	0.67	1.38
	4 #/A	0.67	1.54
EPTC, 5 G	0	4.00	0.17
	2 #/A	3.33	0.08
	4 #/A	3.33	0.21
	8 #/A	1.00	0.21
Trifluralin, 2.5 G	0	2.00	0.00
	2 #/A	2.00	0.38
	4 #/A	1.33	0.75
	8 #/A	2.00	0.46
Vernam, 5 G	0	2.33	0.22
	2 #/A	2.67	0.33
	4 #/A	1.67	0.38
	8 #/A	1.67	0.33

* 0 - No weeds, 10 - 100% weed coverage
** 0 - No injury, 5 - dead

to the petunias was observed in the following treatments: diuron at 1, 2 and 4 pounds per acre and tenoran at 2, 4 and 8 pounds per acre.

In the granular herbicide treated plots good weed control was observed in the following: dichlobenil at 4 and 8 pounds per acre, diphenamid at 8 pounds per acre, diuron at 2 and 4 pounds per acre and EPTC at 8 pounds per acre. Crop injury was noticed in the diuron treatments at 2 and 4 pounds per acre.

The petunias in the diuron and tenoran treated soils initially showed necrosis on the tips and edges of the lower leaves and eventually the entire plant was affected with death resulting in some cases.

The principal weeds in the check plots were yellow foxtail, redroot pigweed, tumble pigweed, lambsquarter, common ragweed and Pennsylvania smartweed. Less frequent weeds were Canada thistle, wild buckwheat, wild carrot, large crabgrass, common purslane, buckhorn plantain, field pepperweed, and whitlowwort.

A number of the herbicide treatments gave good weed control with little or no injury to the petunias. In general for a given rate of application, the sprayed treatments tended to give better weed control than the granular applications. Diuron and tenoran at the rates used gave good weed control but were in general too toxic for petunias.

Summary

Seven herbicides in a liquid form and seven herbicides in a granular form were applied to petunia plantings. Each herbicide was applied at three concentrations plus a check and replicated three times. Several herbicides gave good weed control and in general the sprayed applications tended to produce better weed control than the granular applications. Crop injury was noticed only in the diuron and tenoran treated plots.

A Further Report on the Use of EPTC as a Preplant Treatment

Arthur Bing[1] and A. M. S. Pridham[2]

Research (4,5) and grower trials the past two seasons have shown that preplant soil incorporated applications of ethyl N,N-di-n-propylthiolcarbamate, EPTC have given good control of mugwort (Artemisia vulgaris L.), quackgrass (Agropyron repens (L.) Beauv.) and many other weeds. Adequate mixing of the EPTC and the weed tissue in dry soil to give good contact was essential for good control. Rototilling the EPTC granules in dry soil followed by rain or irrigation gives the best results (14).

EPTC has been very effective against most weeds in nursery areas when used according to directions. Bindweed (Convolvulus Arvensis L.), knawel (Scleranthus annuus L.), and purslane (Portulaca oleracea L.) were not effectively controlled. Pridham (14) found that young liners of Juniperus horizontalis, Taxus media hicksii, Forsythia intermedia, Euonymus fortunei and Hedera helix could be safely planted within a week after application of EPTC. There was little evidence to indicate poor growth of nursery liners planted at least 3 months after the incorporation of adequate EPTC for control of Artemisia vulgaris or Agropyron repens. Preplant treatments of EPTC have reduced vigor of deciduous shrubs but postplant treatments had little or no effect on subsequent growth (15). Ahrens (1) reports good temporary control of nut sedge (Cyperus esculentus L.) by the use of EPTC 5 lb aia.

There has been some injury this past season to smaller plants put into EPTC treated soil. Some plants were put into soil from 5-30 days after treatment. In a previous publication (5) it was stated that the safe waiting period may be variable and the grower should determine if the treated soil is safe for a particular crop before large scale planting. A good indicator is oats (Avena sativa) which germinate but do not grow in soil with an appreciable amount of EPTC. Gladiolus, (Gladiolus hortolanus) also are severely stunted when grown in soil mixed with EPTC. However EPTC in the surface is safely used for weed control over deeply planted gladiolus corms in Florida (17).

There are several factors that influence the effectiveness and persistence of EPTC applications to the soil. Persistence is directly related to the materials used in formulation: more volatile forms lasting the shortest period (7). EPTC applied to dry soil is much more effective and persistent than when applied to moist soil (2,3,7,10,11). High soil moisture prevents penetration of EPTC to the surface of the soil particles (2) and its evaporation can hasten the loss of EPTC from the soil (6). The higher the organic matter in the soil the greater the adsorption of EPTC and the lower its activity (6,12). Microbial activity hastens the breakdown of EPTC (7,16). EPTC affects the shoots of germinating seeds of barnyardgrass (Echinochloa crusgalli) but not ungerminated seeds exposed to EPTC (8,9).

Materials and Methods

Several studies were made to determine the effectiveness against weeds and the safety to nursery stock of soil incorporated EPTC when used as a preplant treatment. Granular and liquid applications of EPTC at 5 to 15 lb aia were made to unplanted nursery soils. Nursery plants and or the test plants red kidney beans, (Phaesolus vulgaris) oats and buckwheat (Fagopyrum esculentum), were planted in the treated soils at intervals after treatment. Soil samples were periodically taken from treated and untreated areas for determination of harmful

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residues.

Field tests in 1963 (14) included the incorporation of EPTC 5 to 15 lb aia from spray and granular sources to control Agropyron repens. The test crops beans, oats, and buckwheat were used in repeated plantings. In October soil samples from 1 to 3 in and 3 to 6 in depths were taken in triplicate, placed in 3 x 5 x 2 in plastic containers that held approximately 2 lb of soil. Samples were planted with beans and oats and grown under greenhouse conditions during the winter (14) and then the soil was replanted in spring with #6 gladiolus corms of variety Friendship. Fresh weight of foliage was taken after 80 days.

Samples of selected soil types were treated with EPTC in October 1963 and in March 1964 were planted to gladiolus in the greenhouse. The cultures were grown under mist for part of the time, otherwise, they were hand watered as necessary to maintain turgor. The plants were cut at the soil surface and weighed after 80 days growth.

In August 1963, several evergreens and ground covers were removed from 4 in pots and those with heavy root systems on the ball surface were planted using a soil EPTC mix based on 5 lb ai EPTC granular per million pound of soil (15 ppm) which corresponds to 15 lb aia 3 in deep. EPTC and soil were mixed in a small concrete mixer.

Field plots received 30 lbs aia EPTC as a granular surface application for 2 consecutive seasons and were observed for plant tolerance.

Results

The persistence of EPTC as measured by the reduction in growth of gladiolus is shown in Tables 1 and 2. From the data in Table 1 the extent of growth suppression is greatest between untreated with an average yield for the untreated of 8.8 g against yields of 6.5, 6.4, and 6.7 for the various treatment levels. There was a slightly smaller average yield 6.3 and 6.1 from the 3-6 in depth than 6.6 and 6.7 from the 1-3 in depth. There are no differences between granular applications 6.7 and 6.1 and the spray applications 6.6 and 6.3. The results indicate some EPTC has persisted from the time the soil was treated in the field to the time in the greenhouse after the oats, beans and buckwheat were grown. Growth of gladiolus was reduced more in subsoil from the 3-6 in depth than in soil from the surface 1-3 in. The number of corms growing in untreated soil averaged 4.9 out of 5 planted in the control and 4.3 in the poorest case for top soil EPTC 5 lb aia. The growing plants averaged 4.5 for all subsoil containers.

The effect of soil type and EPTC on fresh weights and numbers of growing gladiolus plants is shown in Table 2. Growth was less through this series than the series shown in Table 1 because the peat and muck soils were too wet for good growth. The small amount of residual EPTC resulted in small or no suppression of gladiolus growth. In general foliage was dwarf with thick hard tissue in the EPTC treatments.

In the experiment where plants from 4 in pots were planted in soil treated with 15 aia EPTC, the plants did not show immediate response but all plants in 15 aia treated soil died during spring 1964. Control or untreated plants free of root contact with EPTC remained alive.

Field plots receiving a surface application of 30 lb aia EPTC granular for two successive seasons have resulted in death of Juniperus horizontalis plumosa

These rates and procedures exceed recommended practices. Rates of 10 lb aia EPTC and lower have not injured woody crops planted a month or longer after treatment of soil at normal moisture 40%F (field capacity). Soil samples taken in September 1964 varied from 4% soil moisture at the surface to 15-20% soil moisture at a depth of 6-9 in. Field capacity approximates 45-50% for the silty clay loam used in these studies.

Tests in 2 nonirrigated nurseries in the summer of 1964 showed there were EPTC residues in the soil for nearly 3 months.

In a few nurseries, growers treated soil with granular EPTC at approximately 15 lb aia and then waited for a period before planting small nursery liners and perennials. In someinstances they were not satisfied with the weed control and suffered plant losses. Table 3 lists some of the plants that they believed were injured by the treatment. It is difficult to accurately determine the amount of EPTC applied, soil moisture content, organic matter content or the waiting period. Several of these soils were very high in organic matter.

Discussion

Dry soils high in organic matter probably retain enough active EPTC for 1-3 months or longer to injure sensitive plants. Good test plants for determining residues are oats, buckwheat and gladiolus. Where high rates (15 lb aia) are used it may be safe to treat the soil in late summer or early fall and not plant until the following spring after the soil has been tested with oat seedlings. Residues from granular applications may be more persistent than those from liquid spray applications. It is probable that in some species EPTC may not affect dormant plant parts such as seed or rhizomes and if the EPTC is dissipated before they start growing they will not be affected as was found by Dawson with barnyardgrass (8,9). It is possible with dry high organic soils to get poor weed control and long residual effects with some sensitive crops.

Table 1. Persistence of EPTC* as measured by reduction of growth of gladiolus**.

Formulation	Soil depth	Fresh weight of gladiolus tops after 80 days growth				
		Soil treatment				Mean of treatment
		0 lb aia	5 lb aia	10 lb aia	15 lb aia	
		g***	g	g	g	g
Spray	0-3"	9.0	6.6	5.9	7.5	6.6
	3-6"	8.6	5.7	6.3	6.8	6.3
Granular	0-3	9.0	7.1	6.3	6.7	6.7
	3.6	8.6	6.5	5.8	5.9	6.1
Mean wt of rate		8.8	6.5	6.4	6.7	6.4

* Soils treated in July to Sept. 1963 planted to oats, beans, and buckwheat in October in the greenhouse and gladiolus in March 1964.

** Number 6 corms ($\frac{1}{2}$") variety Friendship.

*** Mean fresh weight of 3 replicates of 5 corms each.

Table 2. Effect of soil type and herbicide formulation on the persistence* of EPTC as measured by the growth of gladiolus**.

Soil source	Fresh wt of gladiolus tops after 80 days growth: Soil treatments lb aia EPTC 0	5 Liq	5 Gran	15 Liq	15 Gran	Soil mean for all treatments: Weight	Number of corms growing
	g***	g	g	g	g	g	
Native peat	1.5	0.9	0.9	0.5	0.5	0.7	3.0
Muck	1.1	1.5	1.6	1.0	2.3	1.6	4.3
Bank sand	1.2	1.7	1.6	1.6	1.8	1.7	4.7
Sandy loam	2.1	1.7	1.6	1.6	1.8	1.7	4.0
Greenhouse soil	1.5	1.0	1.2	1.5	1.4	1.2	4.2
Mean weight	1.48	1.36	1.38	1.25	1.56		
Treatment means of number of corms growing for all soils	4.2	4.2	4.2	3.7	4.0		

* Soil treated in October 1963 planted to gladiolus March 1964

** Number 6 corms ($\frac{1}{2}$") variety Friendship.

*** Mean fresh weight of 3 replicates of 5 corms each.

Table 3. Partial list of plants in nurseries injured by a preplant treatment of EPTC 10-15 lb aia

Scientific name	Common name	Interval between treatment and planting date weeks
Alyssum saxatile	basket of gold	6
Aquilegia sp.	columbine	3-6
Iberis sempervirens	candytuft	3-4
Juniperus horizontalis	creeping juniper	3-4
Phlox desicata	phlox	3-4
Pinus mugo	Mugo pine	3-4
Rhododendron obtusum	azalea	1
Vinca minor	myrtle	3-4

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CHEMICAL CONTROL OF MUGWORT

S. W. Bingham[1]

ABSTRACT

Several experiments were conducted for Artemisia vulgaris L. (mugwort) control from April, 1962, until October, 1964. Effective control of mugwort was obtained with 2,3,6-trichlorophenylacetic acid (fenac) and 4-amino-3,5,6-trichloropicolinic acid (picloram). Dimethylamine salt of 2-methoxy-3,6-dichlorobenzoic acid (dicamba) gave control when applied in April, but was less effective later in the season. The amount of fenac necessary for effective control was reduced by mixing with dicamba, butoxyethanol ester of 2,4-dichlorophenoxyacetic acid (2,4-D) or oleyl 1,3-propylene diamine salt of 2,4-D (2,4-D, OPDS). Late in the season, fenac was more effective when applied six weeks after mowing than when applied to large mugwort. Soil incorporated ethyl N-N-di-n-propylthiolcarbamate (EPTC) and n-propyl di-n-propylthiolcarbamate (R-1607) reduced mugwort stands and rhizome population; however, regrowth occurred in the same season.

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CONTROL MEASURES FOR POLYGONUM CUSPIDATUM SIEB. AND ZUCC. AND FOR POLYGONUM SACHALINENSE F. SCHMIDT

A. M. S. Pridham[1]

In 1963 several herbicides were used both as a foliar spray and as a basal spray in July on 100 square foot plots of Polygonum cuspidatum (3,4). The picolinic acid derivative, Tordon, and the benzoic acid derivative Banvel D (dicamba) used at 5 lbs. aia and 10 lbs. aia resulted in death of these knotweeds prior to the growing season of 1964. Japanese knotweed, P. cuspidatum, is well known. Sacaline knotweed is found in several locations in Steuben County, New York near Bath and North Cochocton. Inspection of the plots included digging up roots of the 1963 plants and examining them for live buds and rhizomes. No live parts were found and shoots usually failed to grow in the 2 foot paths between adjacent treated plots. Dead rhizomes were found in both plots and paths. Soil samples were taken in July 1964, a year after treatment. Garden beans were planted in these soil samples taken from the plot surface and below to 6" depth. The cultures were grown in a greenhouse and watered by intermittent misting.

The growth characteristics of the garden bean, Phaseolus vulgaris L. were taken as evidence of the presence of the herbicide. Growth response was noted in both seedling and trifoliate leaves and is recognizable from the illustration in "Tordon Information Manual," Dow Chemical Company (1). Growth behavior at a specific stage corresponds with that described by W. A. Gentner (2) in the July issue of "Weeds."

Leaf shape is modified by exposure to vapor or spray in amounts less than 5 ppm. Beans growing in treated soil may show response at germination or later. Thickening and cupping of the leaves and extension of the leaf tip and other serration sites, are common response to 5 ppm as a spray. Arrest of terminal or expanding growth and fixing or setting of stem curvature and development of fleshy and corky tissue are common from germination stage to flowering as related to the amount of chemical, 100 ppm, and to rapidity of expansion or cell division.

Control plants growing in untreated soil showed no deviation from normal leaf shape and growth habit. They averaged 16" in height and 5.6 grams in weight.

Beans growing in soil from Tordon treated plots showed a range of growth modification though not all bean plants in a culture responded to the same degree. Response usually (5 out of 6 cases) was greater in soil samples from 3-6" level than from 0-3", and more severe when 2,4-D was combined with picolinic acid in the formulation Tordon 101 as compared to the same weight of picolinic acid from formulation Tordon 22K. Few bean plants grew beyond juvenile foliage stage and weighed 2-3 grams. Beans growing in soil from Banvel D treated plots weighted less than controls (4.7 grams as an average) but otherwise showed symptoms similar to those associated with Tordon and described above.

P. sachalinense was controlled by Tordon and by Banvel D at 5 lbs. aia in 1963 plots in North Cohocton, New York. Japanese knotweed was controlled

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in plots at Richford, N. Y. in two locations; Ithaca, N. Y. in three locations; and Niles, N.Y. at one location. Failure at one location was associated with Polygonum growing in 2 feet or more of coal ashes. Plots on soil adjacent to the ashes responded to Tordon.

In June 1964 plots were set out using lower rates of Tordon and of Banvel D. Examination of Polygonum rhizomes indicates that at levels below 1 aia control is less likely than at 1 aia or more of either chemical.

Polygonum regrowth in July or later responds differently than expected from basal spray of normal plants. Repeated spot spraying is to be expected if the weed is to be eliminated. Otherwise repeated mowing encourages the plant to spread from buds that would otherwise remain dormant on the enlarging rhizomes.

Granular formulations of Tordon induce typical foliage response but little or no mortality of foliage under dry weather conditions of 1964.

Control of Polygonum with plastic mulch. In 1961 before dicamba or picolinic acid were recognized as effective in control of Japanese bamboo, a suggested treatment included the following steps: 1) dig out existing plants by hand or machine, 2) lay black plastic over the cleaned area, holding the plastic in place with soil or stones, etc., and 3) leave the plastic in place for two seasons before removal.

A letter was received in July 1964 indicating that this treatment had been followed and raised the question of removing the plastic. Inspection of site indicated that two layers of black plastic had been used and were held in place by flagstone laid along the margins of the plastic. Plastic had been used in two locations, one in 1961 and the second in 1962. The second was flanked by dry stone walls along two sides and a few short stems of P. cuspidatum were present, along these walls in which roots can grow.

Dry dead roots of Polygonum were uncovered by careful digging and served to indicate that a stand of this plant had occupied both sites. Thus by following instructions and doing a good job so that the plastic remained undisturbed by the weather, by animals and children, etc., Polygonum can be controlled or eliminated without using chemicals or using permanent cover of asphalt or concrete sometimes used to enlarge a parking or terrace area.

For practical purposes the use of either Banvel D or Tordon in amounts of 1 lb. aia used at the close of the growing season, September or later, can be successful and within limits, without serious hazard in normal soils, and with caution in wet soils, i.e. drainage field from a septic tank or low land with poor drainage.

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FIELD EVALUATION OF PRE-EMERGENCE HERBICIDES ON ESTABLISHED NURSERY STOCK

Craig S. Oliver [1] and Chiko Haramaki [2]

In Pennsylvania approximately 16,000 acres of cropland is used for the production of nursery stock. The annual wholesale value of this crop is more than $6,000,000.

It has been estimated that in the average year a nurseryman will spend approximately $100 - $250 per acre to control weed problems in the nursery. Using this figure it is quickly determined that weed control costs alone are a major production cost factor to the Pennsylvania nurseryman.

Chemical weed control practices can be used to reduce nursery production costs, eliminate plant losses from mechanical injury, and even improve plant quality. The grower, however, is still reluctant to adopt chemical weed control practices.

Grower skepticism has been to a large extent justified, and unless available weed control research data can be readily assimilated by him, field application of research data will be limited.

There exists a need for extensive field evaluation and demonstration of pre-emergence herbicides on a wide spectrum of nursery stock. The following experiment was set up to evaluate several herbicides for use on established nursery plantings.

Materials and Methods

In the fall of 1963, herbicide treatments were made at ten nursery sites under variable soil and crop conditions. At 5 of the nurseries herbicides were applied to selected broadleaf evergreen species, 3 nurseries were selected for evaluation of herbicides on narrowleaf evergreen species and 2 were used for evaluation of herbicides on narrowleaf evergreen species.

Species used were:

Ilex opaca
Leucothoe catesbaei
Pieris japonica
Rhododendron atropurpurea
Rhododendron catawbiense album
Rhododendron english roseum
Rhododendron sargentianum

Juniperus chinensis pfitzeriana hetzi
Taxus cuspidata densiformis
Taxus media mooni columnaris
Thuja occidentalis globosa

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Species used were:

Acer platanoides schwedlier nigra
Acer saccharinum
Acer saccharum
Cornus stolonifera
Viburnum opulus nanum

All plant species where herbicides were applied had been growing in the nursery row a minimum of one year before herbicide treatments were made. 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. Herbicide materials had never been previously applied to these treatment areas.

The following herbicides were compared in this test:

a. Amiben - 10% granular
b. CIPC - 5% granular
c. DCPA - 50% wettable powder
d. Dichlobenil - 4% granular
e. Diuron - 2% granular
   80% wettable powder
f. SWEP - 5% granular
   80% wettable powder
g. Vernam - 10% granular
h. Simazine - 4% granular
i. Amizine - 60% wettable powder
j. Atrazine - 8% granular

The granular materials were applied by hand spreading, since the quantities applied were too small for accurate use of mechanical applicators. 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.

Results

During June, 1964, which was 8 months after treatment, all plots were examined for weed prevalence.

Weed control in broadleaf evergreen species

Dichlobenil and Diuron provided effective spring and early summer weed control at all the test sites.

Amiben, CIPC, DCPA and Vernam were erratic in their ability to effectively control weed growth. This variation probably resulted from the selectivity of each herbicide and the varying soil types.

Although, the weed species present reacted differently to the herbicides, the most difficult weeds to control in all the plots were annual bluegrass and common chickweed.

No injury was apparent on any of the plant species where herbicides were applied.

The herbicide treatments and their effects on weed control is summarized in Table 1.

Weed control in narrowleaf evergreen species

Dichlobenil, Diuron, Amizine and Simazine all provided effective spring and summer weed control. Dichlobenil, however, was especially effective against dandelion which persisted in the row of many of the plots.

No injury was apparent on any of the plant materials where herbicides were applied. The varying soil types and soil conditions also appeared to have little effect upon the herbicide materials' ability to give effective weed control. SWEP and Amiben, however, did have a tendency to show erratic control when used on varying soil conditions.

The herbicide treatments and their effects on weed control is summarized in Table 2.

Weed control in deciduous shrub and tree species

The outstanding treatment with regard to duration and effectiveness of weed control was Dichlobenil.

Atrazine and Simazine also provided good weed control. However, perennial weeds such as quackgrass and dandelion persisted while in the Dichlobenil plots dandelions were eliminated and quackgrass was reduced.

Diuron provided good weed control at one nursery test site, but poor control was exhibited at the other. The erratic control was the result of perennial weed growth which occurred after the plots were clean cultivated and herbicides applied.

Amiben and SWEP provided poor weed control at all nursery test sites.

Cornus stolonifera and *Viburnum opulus nanum* showed injury from applications of Dichlobenil and Atrazine at rates of 8 lbs. and 3 lbs. per acre respectively. Both species were apparently stunted, and discoloration of foliage was noted. No injury was apparent from other treatments.

TABLE 1. EFFECT OF FALL HERBICIDE APPLICATIONS ON WEED CONTROL IN ESTABLISHED BROADLEAF EVERGREEN SPECIES [1]

(Treatment October, 1963 - Checked June, 1964)

Herbicide and Formulation	Rate a.i. lbs./A.	Weed Control Rating [2] SITE 1	2	3	4	5	Average [3] Weed Rating	Weed Prevalence [4]
Dichlobenil 4% G	6	0.0	0.5	1.0	0.5	0.5	0.5	Annual bluegrass, quackgrass
Diuron 2% G	2	3.0	2.0	1.0	1.5	1.5	1.8	Common chickweed, annual bluegrass, common ragweed, dandelion
CIPC 5% G	10	4.0	6.0	8.0	3.0	4.0	5.0	Annual bluegrass, common chickweed, common purslane, quackgrass, common lambsquarters
SWEP 5% G	6	8.0	5.0	1.0	5.0	7.0	5.2	Annual bluegrass, common chickweed, quackgrass, shepherdspurse
Vernam 10% G	10	3.0	9.0	3.0	6.0	9.0	6.0	Common chickweed, common ragweed, sheepsorrel, curly dock
DCPA 50% W.P.	15	2.0	---	10.0	7.0	7.0	6.5	Common chickweed, annual bluegrass, shepherdspurse, yellow rocket
Amiben 10% G	10	9.0	9.0	10.0	5.0	2.0	7.0	Annual bluegrass, common chickweed, field peppergrass, sheepsorrel
Check	--	10.0	10.0	10.0	10.0	10.0	10.0	Common chickweed, annual bluegrass, common ragweed, sheepsorrel, quackgrass, field peppergrass

1 *Leucothoe catesbaei*, *Ilex opaca*, *Rhododendron catawbiense album*, *Rhododendron english roseum*, *Rhododendron atropurpurea*, *Rhododendron sargentianum*, *Pieris japonica*

2 Weed Prevalence Scale: 1 = 10% or less weed coverage 10 = 100% weed coverage

3 Weed ratings taken June, 1964

4 Weeds present in a decreasing order of frequency

TABLE 2. EFFECT OF FALL HERBICIDE APPLICATIONS ON WEED CONTROL IN NARROWLEAF EVERGREEN SPECIES 1

(Treatment October, 1963 - Checked June, 1964)

Herbicide and Formulation	Rate a.i. lbs./A.	Weed Control Rating 2 SITE 1	SITE 2	SITE 3	Average 3 Weed Rating	Weed Prevalence 4
Dichlobenil 4% G	8	0.0	0.5	0.0	0.3	Black medic
Atrazine 8% G	3	0.0	1.0	1.0	0.7	Dandelion, crabgrass
Amizine 60% W.P.	4	---	1.0	1.0	1.0	Dandelion
Diuron 80% W.P.	3	0.0	2.0	1.0	1.0	Dandelion, field bindweed, chicory, common purslane
Simazine 4% G	3	---	4.0	1.0	2.5	Dandelion, yellow rocket, common purslane
SWEP 80% W.P.	8	0.0	7.0	2.0	3.0	Shepherdspurse, dandelion, field bindweed, field peppergrass, common ragweed, common lambsquarters
Amiben 10% G	10	9.0	6.0	5.0	6.7	Tall oatgrass, dandelion, shepherdspurse, common ragweed, Pennsylvania smartweed, sheepsorrel
Check	--	10.0	10.0	10.0	10.0	Shepherdspurse, wild carrot, common ragweed, common lambsquarters, dandelion, timothy, Pennsylvania smartweed

1 Taxus media mooni columnaris, Thuja occidentalis globosa, Juniperus chinensis pfitzeriana hetzi
2 Weed Prevalence Scale: 1 = 10% or less weed coverage 10 = 100% weed coverage
3 Weed ratings taken June, 1964
4 Weeds present in a decreasing order of frequency

TABLE 3. EFFECT OF FALL HERBICIDE APPLICATIONS ON WEED CONTROL IN DECIDUOUS SHRUB AND TREE SPECIES [1]

(Treatment October, 1963 - Checked June, 1964)

Herbicide and Formulation	Rate a.i. lbs./A.	Weed Control Rating [2] SITE 1	SITE 2	Average [3] Weed Rating	Weed Prevalence [4]
Dichlobenil 4% G	8	0.0	1.0	0.5	Yellow rocket, quackgrass
Atrazine 8% G	3	2.0	2.0	2.0	Dandelion, quackgrass, sheepsorrel, timothy
Simazine 4% G	3	1.0	5.0	3.0	Dandelion, sheepsorrel, curly dock, timothy, goldenrod, field peppergrass
Diuron 80% W.P.	3	1.5	7.0	4.2	Quackgrass, dandelion, ground ivy, broadleaf plantain
Amiben 10% G	10	9.0	9.0	9.0	Field peppergrass, tall oatgrass, shepherdspurse, ground ivy, hop clover, common ragweed, quackgrass
SWEP 80% W.P.	8	10.0	9.5	9.7	Field peppergrass, sheepsorrel, timothy, oxeye daisy, prickly lettuce
Check	--	10.0	10.0	10.0	Field peppergrass, tall oatgrass, shepherdspurse, ground ivy, common ragweed, quackgrass, sheepsorrel

1 *Acer platanoides schwedleri nigra*, *Acer saccharinum*, *Acer saccharum*, *Cornus stolonifera*, *Viburnum opulus nanum*

2 Weed Prevalence Scale: 1 = 10% or less weed coverage 10 = 100% weed coverage

3 Weed ratings taken June, 1964

4 Weeds present in a decreasing order of frequency

Summary

Several herbicides were evaluated at ten nursery sites under variable soil and crop conditions. The herbicide materials were applied to selected broadleaf, narrowleaf, deciduous shrub and tree species in October.

Dichlobenil at the rate of 6 and 8 lbs. of active ingredient per acre appears to be an excellent broad spectrum herbicide when applied in the fall for spring and summer weed control. *Cornus stolonifera* and *Viburnum opulus nanum* showed signs of plant injury at the 8 lbs. per acre rate.

Diuron granular and wettable powder at the rate of 2 lbs. and 3 lbs. per acre provided good weed control at most test sites. It did not, however, give the broad spectrum control exhibited by Dichlobenil. The varying soil types, soil conditions and moisture levels present in the soil appeared in some cases to affect the herbicidal action.

Amizine, Atrazine and Simazine provided effective weed control on all test plots where used. Injury was noted in the form of discoloration and stunting of plants in plots where Atrazine was applied to *Cornus stolonifera* and *Viburnum opulus nanum*.

GRANULAR HERBICIDES FOR WEED CONTROL IN CONTAINER-GROWN WOODY ORNAMENTAL PLANTS[1]

Harold Davidson and S. K. Ries[2]

The production and marketing of woody ornamental plants in containers is rapidly growing in importance (1, 4). One of the major problems in the production of container-grown plants is the economic control of weeds. Many nurserymen effectively control weeds for one season or a portion thereof by using a sterile media (1). However, where sterile media is not used or where the plants are grown in the container for relatively long periods of time, weeds become a serious pest. These experiments were undertaken to evaluate the use of several selected granular herbicides for controlling weeds about container-grown nursery stock.

A series of three experiments was conducted at the Michigan State University Horticulture Farm, East Lansing and one experiment was conducted in the container-production area of the Zelenka Evergreen Nursery in Grand Haven, Michigan. Weed species that were associated with these tests are tabulated in Table 1.

The first test, at the Horticulture Farm, evaluated the effectiveness of five herbicides for the controlling of weeds associated with container-grown plants. Rosa hybrida and Euonymus fortunei vegetus were planted into seven inch "Herculite" nursery pots using a media composed of peat and sand mixed in a 1-1 ratio by volume. Metal ammonium phosphate (8-40-0) used at the rate of ten pounds per cubic yard was blended with the media prior to planting (3). The appropriate amount of each granular herbicide was applied volumetrically to each container. The herbicides were applied either immediately or three weeks after planting to determine the best time for application with the least amount of injury. The treatments were replicated three times in a completely randomized design. The treatments and the weed control ratings eight weeks following application are tabulated in Table 2.

The weed density rating eight weeks after application indicated that all the herbicides gave commercially acceptable weed control. However, phytotoxic symptoms in the form of a chlorosis of the leaves of Euonymus fortunei vegetus developed as a result of the simazine treatments which had been applied three weeks after planting. And the Euonymus plants treated immediately following planting with simazine were completely defoliated. Plants in all of the other treatments were vigorous and had good foliage color. Ratings made thirteen weeks after initial application of the herbicide followed a pattern similar to those reported in Table 2.

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[1]Paper number 3508. Michigan Agr. Exp. Sta. East Lansing, Michigan.
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The second test, conducted at East Lansing was made to evaluate the response of five species to two herbicides: dichlobenil and simazine, applied to the surface of container-grown woody ornamental plants. Forsythia intermedia and Euonymus fortunei vegetus were selected for their known sensitivity to simazine (5). Rosa hybrida and Taxus cuspidata expansa were selected because they are relatively tolerant of simazine (2, 5) and because both are produced in great quantity as container-grown plants by nurserymen. Pachysandra terminalis was used because this species is an excellent ground cover which lends itself to container production but weed control is a problem. The media, fertilizer, planting, and herbicide application were similar to that outlined in the first test. Four replications of each treatment were made and the plants grown in a completely randomized design.

Analysis of the weed control ratings made September 9, thirteen weeks after application, indicated that both herbicides at both rates gave excellent control of weeds. No phytotoxic symptoms from dichlobenil developed on any species. However, of the species treated with simazine, three exhibited phytotoxic symptoms: at 4 lb/A Forsythia developed a severe chlorosis of the foliage; Euonymus was defoliated; and Pachysandra exhibited a necrosis of the leaf margin. The Forsythia and Euonymus treated with the 2 lb/A were slightly chlorotic shortly after treatment but regained their normal foliage color by the end of August.

In the third experiment at East Lansing, dichlobenil and simazine were applied to container-grown Roses and Euonymus grown in clay loam, sandy loam, and a sand-peat mixture to determine if the herbicides would be equally effective on the various medias and whether or not any phytotoxic responses might be related to a media-herbicide interaction. The herbicide treatments were applied immediately following planting and were replicated four times in a completely randomized design.

Both herbicides gave excellent weed control, and were equally effective on all three soil types. No media-herbicide interaction was observed. Weed density was greatest in the untreated clay soil containers. Euonymus fortunei vegetus was defoliated in almost all the containers that received 4 lb/A of simazine. No phytotoxic symptoms were observed on the Roses.

The experiment at the Zelenka nursery was made to test the effectiveness of the various granular herbicides under another environment and set of cultural practices. Since the plants grown in the container-production area at the nursery were arranged in large blocks by species, the treatments were completely randomized within each of five species, using four replications, and the data analyzed as five separate experiments. The media was composed of a 1-1 mixture of Lake Michigan dune sand and Michigan peat. The containers were irrigated as necessary and

fertilized once each month with a surface application of a 20-8-5 fertilizer. The treatments and the weed control ratings are summarized in Table 3.

Weed control was excellent with simazine and dichlobenil at all rates and with trifluralin at 4 lb/A. Trifluralin at 2 lb/A and diphenamid at 4 lb/A were not as effective in this test. The only visible symptoms of phytotoxicity was a moderate chlorosis of the Euonymus fortunei vegetus from the higher rate of simazine.

Conclusions

Weeds may be effectively controlled in container-grown woody ornamental plants by the use of certain granular herbicides. Dichlobenil at 2, 4, or 8 lb/A, simazine at 2 or 4 lb/A, trifluralin at 4 lb/A, all gave excellent control. Trifluralin at 2 lb/A and diphenamid at 4 lb/A were not as effective.

Phytotoxic symptoms observed were all associated with the simazine treatments. Forsythia intermedia exhibited chlorosis of the foliage, Euonymus fortunei vegetus suffered from chlorosis and defoliation, and Pachysandra terminalis showed a marginal necrosis.

Rosa hybrida, Taxus cuspidata expansa, Berberis thunberg, Juniperus "Pfitzeriana", and Leucothoe catesbaei exhibited no visable phytotoxic symptoms to any of the treatments applied.

The two herbicides, dichlobenil and simazine, tested for a soil type-herbicide interaction exhibited no such interaction. Both gave excellent weed control on the three soil types tested.

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Table 1. Weed species associated with the 1964 Granular Herbicide Tests for Container-Grown Woody Ornamental Plants.

Botanical Name	Common Name	East Lansing	Zelenka Nursery
Agropyron repens	Quackgrass	-	+
Ambrosia artemisiifolia	Common Ragweed	-	+
Capsella bursa-pastoris	Shepherd's Purse	+	+
Chenopodium album	Lamb's Quarters	+	+
Convolvulus arvensis	Field Bindweed	-	+
Digitaria ischaemum	Smooth Crabgrass	+	+
Digitaria sanguinalis	Crabgrass	+	+
Echinochloa crusgalli	Barnyard Grass	+	+
Lactuca canadensis	Wild Lettuce	-	+
Lepidium virginicum	Peppergrass	-	+
Oxalis europaea	Yellow Wood Sorrel	-	+
Panicum dichotomiflorum	Spreading Panicgrass	-	+
Plantago lanceolata	Buckhorn Plantain	+	+
Polygonam hydropiper	Common Smartweed	+	+
Poa annua	Annual Bluegrass	+	+
Portulaca oleracea	Purslane	+	+
Stellaria media	Common Chickweed	+	+
Taraxacum officinale	Dandelion	+	-
Trifolium sp.	Clover	-	+

Table 2. Effect of Granular Herbicides on Weed Control[1] Eight Weeks After Application to Container-Grown Roses and Euonymus.

Herbicide	Rate (lb/A)	Weed Control
None	0	4.8 c
dichlobenil	4	9.0 a
dichlobenil	8	9.0 a
dichlobenil	12	9.0 a
simazine	2	8.8 a
simazine	4	9.0 a
diphenamid	4	8.1 a b
diphenamid	6	7.7 a b
trifluralin	2	6.8 b
trifluralin	4	7.2 a b
diphenamid & trifluralin	3.2 & 0.8	7.3 a b
diphenamid & trifluralin	4.8 & 1.2	8.4 a

[1]Rating Scale 1-9: 1 = no control, 6 = commercially acceptable control, 9 = weed erradication.

Values in columns followed by the same letter are not different by odds of 99-1. Values not followed by the same letter are different by odds of 99-1.

Table 3. Effect of Granular Herbicides on Weed Control[1] 13 Weeks After Application to Selected Container-Grown Woody Ornamental Plants.

Herbicide	Rate lb/A	Berberis	Euonymus	Juniper	Levcothoe	Taxus
None	0	3.3c	3.3b	5.3b	2.8b	4.0b
dichlobenil	2	8.5a	9.0a	8.0a	8.3a	8.5a
dichlobenil	4	9.0a	9.0a	8.0a	9.0a	9.0a
dichlobenil	8	9.0a	9.0a	8.8a	9.0a	9.0a
simazine	2	7.5a	8.0a	8.0a	8.0a	7.8a
simazine	4	9.0a	8.8a	8.8a	9.0a	9.0a
diphenamid	4	6.3b	5.3b	5.5b	4.0b	7.5a
diphenamid	6	8.0a	5.3b	6.0a	4.3b	7.8a
trifluralin	2	6.5b	4.5b	7.5a	3.0b	7.0a
trifluralin	4	7.5a	8.3a	7.3a	6.8a	8.8a

[1]Rating Scale 1-9: 1 = no control, 6 = commercially acceptable control, 9 = weed erradication.

Values in columns followed by the same letter are not different by odds of 99-1. Values not followed by the same letter are different by odds of 99-1.

HERBICIDE COMBINATIONS FOR SUMMER WEEDS IN NURSERY CROPS[1]

J. R. Havis, W. J. Bennett, and R. D. Fitzgerald[2]

Nurserymen who have been using simazine for a number of years have had increasing crabgrass infestations in their fields. A herbicide is needed that is particularly effective against crabgrass and other annual grasses as well as broadleaved weeds. Also needed is a herbicide that can be used safely on deciduous shrubs, azaleas, and other crops considered to be sensitive to simazine. A safe, effective material is especially needed for application immediately after setting small plants, for control of the first flush of weeds.

Rosengren, et al (3), using a logarithmic sprayer indicated that dacthal and diphenamid were effective against annual grasses, but not against broadleaved weeds. Ahrens (2) reported good control of crabgrass in nurserys with diphenamid, and excellent weed control with a combination of diphenamid 4 lbs. and simazine 1 lb. per acre. Ahrens (1) found diphenamid and dichlobenil to be safe on a number of deciduous shrubs. Simazine has proven to be highly effective against many of the annual broadleaved weeds found in the nursery.

The purpose of these studies was to find a control for a wide range of weed species, with safety to a large number of crop species by combining a low rate of simazine with certain other chemicals that are promising for controlling grasses.

MATERIALS AND METHODS

Eight replicated experiments were conducted on nurseries across the state of Massachusetts; the same treatments were used where it was feasible to do so. This method of testing has a good chance of covering a wide range of soil, weather, and cropping conditions and is well adapted to a state-wide Extension Program. The test areas are listed in table 1 along with soil moisture conditions, predominant weeds, and crops. The applications were made during May and June, except for one at the end of July. Data on weed control were recorded 1 to 3 months, but usually 6 or 8 weeks later.

Five of the trials were conducted on established plants that had just been thoroughly cultivated and weeded. In the other 3 trials, the applications followed immediately after the plants were set. Individual plot size varied from 260 sq. ft. in trial A to 38 sq. ft. in trial F (table 1). Randomized block designs were used with 2 or 3 replications. The following herbicides and combinations were used:

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[1] Contribution of the Massachusetts Agricultural Experiment Station, Amherst.

[2] Cooperative Extension Service, located respectively Amherst, West Springfield, and Hathorne, Massachusetts.

Table 1. Details of the 8 trials conducted in nurseries across the state of Massachusetts.

Nursery	Kind of Soil	Soil moist. at appl.	Crops	Predominant Weeds	Date of appl.	Date Obse
A (Belchertown)	Loam	Dry surface, moist under	Misc. shrubs[1] (newly set)	Barnyard grass, foxtail, crabgrass, lambs quarter, pigweed, purslane.	5/8	7/
B (Lee)	Sandy loam	Moist	Ornamental trees[2] (estab.)	Pigweed, purslane, crabgrass.	6/9	8/
C (Feeding Hills)	Fine sandy loam	Moist	Taxus species (estab.)	Crabgrass, ragweed, purslane, foxtail.	6/11	9/
D (Turners Falls)	Sandy loam	Dry surface, moist under	Spreading Yew Pfitzer juniper (estab.)	Purslane, pigweed.	7/1	8/
E (Hopkinton)	Clay loam	Soil moist, light mulch on surface	Mountain laurel (estab.)	Crabgrass	6/10	7/
F (Hopkinton)	Clay loam	Moist	Carolina rhododendron (newly set liner seedlings)	Crabgrass, barnyard grass, lambs quarters, purslane, pigweed, oxalis, chickweed sorrel.	6/10	7/
G (Beverly)	Sandy loam	Dry surface, irrig. foll.	Delphinium (estab.)	Purslane, lambs quarters, crabgrass.	7/31	8/
H (Amherst)	Fine sandy loam	Dry surface	Several broad-leaved ever-greens[3] (Newly set)	Purslane, pigweed, galinsoga	5/28	7/

[1] Poukhanense azalea, Viscosa azalea, Catawba rhododendron, hybrid lilac, winged euonymus, Ibolium prive Spectabilis forsythia.

[2] Flowering crab, flowering plum, Mountain Ash, Crimson King Maple.

[3] Catawba rhododendron, Carolina rhododendron, Mt. laurel, Mt. andromeda, Japanese andromeda, Hinodegari azalea.

		Lbs./A a.i.	Wettable Powder	Granular
1.	simazine	2	80%	4%
2.	dichlobenil	4	50	4
3.	diphenamid	6	80	5
4.	simazine &	1	80	4
	dichlobenil	2	50	4
5.	simazine &	1	80	4
	diphenamid	4	80	5
6.	simazine &	1	80	4
	dacthal	10	75	5

Wettable powder formulations were used in 5 trials, where the combinations were applied as tank mixes. Granulars were used in 3 trials, where each chemical was applied separately by hand.

Provisions were made to obtain growth data on some of the species at area A. At the time of setting the plants on May 7, the forsythia and privet plants were cut to a uniform height of 24", and the euonymus plants were cut to 12". Height measurements were recorded in each plot at the end of the season.

RESULTS AND DISCUSSION

Weed control in the trials, summarized in table 2, was rated on the basis of 9 for perfect control, 7 for "commercial" control, and 1 for no control.

The check plots in table 2 were given ratings of 1.0 if the weed population was about normal. It will be noted that the check plots in trial areas B and C had grass ratings of 4.5 and 5.0, indicating about 50% stand. Thus, these two trial areas did not provide a severe test of the chemicals for annual grasses. No ratings are given in trial areas where weeds were particularly sparse.

Three of the trial areas, A, F, and G had a sufficient range of weed species and population to provide good tests for the chemical. The generally lower ratings in area E may have been due to a light organic mulch, which could have prevented part of the applied chemicals from reaching the soil.

Examination of the average ratings for all of the trials indicates that dichlobenil alone and diphenamid alone gave poorer broadleaved weed control than the other treatments. Simazine alone and dichlobenil alone were low in grass control. The three combinations of chemicals gave average ratings above 7, or commercial control, for both kinds of weeds.

Two of the combination treatments: simazine 1 lb. + diphenamid 4 lbs., and simazine 1 lb. + dacthal 10 lbs. appeared to be especially promising. These two treatments gave broadleaved weed control about

Table 2. Average weed control ratings for herbicides and combinations in 8 replicated experiments.[1]

Treatment[2] (lbs./acre)	A[3] BL	A[3] Gr.	B BL	B Gr.	C Gr. Only	D BL Only	E Gr. Only	F (Gran.) BL	F (Gran.) Gr.	G (Gran.) BL	G (Gran.) Gr.	H (Gran.) BL Only	Averag BL	G
1 Simazine 2	8.0	6.2	----		7.0	9.0	2.0	8.3	7.6	7.5	7.0	--	8.2	6
2 Dichlobenil 4	8.5	6.3	5.5	7.0	7.0	5.5	4.5	8.0	7.0	7.5	6.0	5.0	6.7	6
3 Diphenamid 6	4.5	5.7	7.0	8.5	8.0	3.5	6.0	7.6	7.3	6.0	5.5	--	5.7	6
4 Simazine 1 +Dichlobenil 2	8.7	6.3	8.5	9.0	8.0	8.0	--	----		----		--	8.4	7
5 Simazine 1 +Diphenamid 4	7.5	7.7	9.0	9.0	8.0	9.0	6.5	9.0	8.3	7.5	8.0	8.5	8.4	7
6 Simazine 1 +Dacthal 10	6.5	7.0	9.0	9.0	9.0	9.0	7.0	8.6	8.0	8.0	8.5	7.0	8.0	8
7 Check	1.0	1.0	1.0	4.5	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2

[1] Rating system: 9 perfect control, 7 "commercial" control, 1 no control.

[2] Chemicals were applied as wettable powders, except locations F, G, and H, where granular formulations were used.

[3] Letters signify different nursery locations, where experiments were conducted.

Although the combination treatment, simazine 1 lb. + dichlobenil 2 lbs., had good average control ratings for both weeds and grasses, conclusions should be reserved for further tests. Unfortunately, this treatment was included in only 4 trials, only one of which, area A, provided a severe test against grasses. In that trial this combination fell considerably below the other two combinations in grass control.

Wettable powder and granular formulations were not compared directly. However, the results of the different experiments, presented in table 2, suggest that the combinations of chemicals in granular form were fully as effective as wettable powders.

At the end of the season, no injury symptoms appeared to be associated with treatments at any of the trial areas. Height measurements of nursery plants at area A, taken October 21 do not indicate growth retardation from any of the herbicide treatments. The height of the forsythia plants in the check plots was significantly less than all of the treated plants, probably due to weed competition. Ratings of the condition of rhododendron plants in these same plots were not significantly different. Since no indication of injury was found, further work with the combinations of herbicides is needed to establish their relative safety to nursery crops.

SUMMARY

Eight replicated experiments were conducted in various parts of Massachusetts, in which certain combinations of herbicides were compared with single herbicides for control of summer weeds in nurseries. Two combinations, (a) simazine 1 lb. + diphenamid 4 lbs. and (b) simazine 1 lb. + dacthal 10 lbs., gave good to excellent control of both broadleaved weeds and grasses. They did not produce visible injury on any of the nursery species in the trials. These combinations offer good possibilities for an improvement over simazine alone in the control of a wider range of summer weeds and safety to more nursery crops.

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POST-TRANSPLANT APPLICATIONS OF HERBICIDES IN SCARLET SAGE

Chiko Haramaki and R. P. Meahl[1]

The attractive scarlet sage is popularly used as a bedding plant in flower gardens. Flower gardens like other plant beds are difficult to maintain weed-free. It has been shown that many annual flowers can be grown with little or no injury in soils that have been treated with either pre- or post-transplant herbicides. In past tests, scarlet sage has been observed to be more readily injured by herbicides than many other annual flowers. The objectives of this experiment were to observe the effects of several post-transplant applications of herbicides on weed control and on scarlet sage.

Methods and Materials

This report is a combination of two experiments. In one experiment seven herbicides were sprayed and in the other seven herbicides were applied in a granular form. Each herbicide was applied at three concentrations plus a check and replicated three times. The following herbicides were used:

CIPC, 5 G (Pittsburgh Plate Glass)
Dacthal, 50 W (Diamond Alkali)
Dichlobenil, 4 G, and 50 W (Thompson-Hayward)
Diphenamid, 5 G and 50 W (Upjohn)
Diuron, 2 G and 80 W (Andrew Wilson) (DuPont)
EPTC, 5 G (Stauffer)
Tenoran, 50 W (CIBA)
TH-052H (Thompson-Hayward)
Trifluralin 2.5 G and 4 EC (Eli Lilly)
Vernam, 5 G (Stauffer)

On May 2, 1964 the scarlet sage variety 'Blaze of Fire' seeds were sown and on May 15 they were transplanted to flats. The scarlet sage plants were planted in the field on July 6 and an inch of water was applied. The sprayed treatments were applied on July 20 and the granulars on July 22. The silt loam soil had been rototilled and hand hoed just prior to herbicide application. The air temperature was 85° F and the soil moisture was near field capacity when the spray treatments were applied. The temperature at one inch below the soil surface was 90° F and at six inches it was 80° F.

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Table 1. Effect of post-transplant herbicide spray applications on weed prevalence and on scarlet sage, 1964

Herbicide	Active Rate	Weed Prevalence*	Plant Injury**
Dacthal, 50 WP	0	2.00	0.54
	4 #/A	1.00	0.52
	8 #/A	0.67	1.23
	16 #/A	0.67	0.74
Dichlobenil, 50 WP	0	2.67	0.71
	2 #/A	2.67	0.46
	4 #/A	1.00	0.54
	8 #/A	0.33	0.92
Diphenamid, 50 WP	0	1.33	0.38
	2 #/A	1.33	0.50
	4 #/A	1.33	0.38
	8 #/A	0.67	0.42
Diuron, 80 WP	0	3.00	0.25
	1 #/A	0.00	0.58
	2 #/A	0.00	1.00
	4 #/A	0.00	0.71
Tenoran, 50 WP	0	1.67	0.58
	2 #/A	0.00	0.43
	4 #/A	0.00	0.96
	8 #/A	0.00	1.43
TH-052H, 50 WP	0	2.00	0.61
	2 #/A	2.00	0.77
	4 #/A	1.00	0.29
	8 #/A	0.33	0.75
Trifluralin, 4 EC	0	1.67	0.57
	2 #/A	0.33	0.95
	4 #/A	0.33	0.27
	8 #/A	0.00	1.91

* 0 - No weeds, 10 - 100% weed coverage
** 0 - No injury, 5 - dead

Table 2. Effect of post-transplant applications of granular herbicides on weed prevalence and on scarlet sage, 1964

Herbicide	Active Rate	Weed Prevalence	Plant Injury**
CIPC, 5 G	0	2.67	0.54
	2 #/A	2.33	0.17
	4 #/A	2.00	0.29
	8 #/A	1.33	0.58
Dichlobenil, 4 G	0	5.00	1.00
	2 #/A	1.67	1.33
	4 #/A	0.67	2.00
	8 #/A	1.00	2.77
Diphenamid, 5 G	0	5.33	0.25
	2 #/A	3.33	0.52
	4 #/A	2.67	0.46
	8 #/A	2.00	0.79
Diuron, 2 G	0	3.33	0.42
	1 #/A	2.00	0.33
	2 #/A	1.00	0.38
	4 #/A	0.00	0.21
EPTC, 5 G	0	3.00	0.17
	2 #/A	5.33	0.50
	4 #/A	4.00	0.91
	8 #/A	2.00	1.04
Trifluralin, 2.5 G	0	2.67	0.61
	2 #/A	1.33	0.57
	4 #/A	1.00	0.58
	8 #/A	1.00	0.43
Vernam, 5 G	0	3.00	0.54
	2 #/A	3.00	1.00
	4 #/A	2.67	0.71
	8 #/A	2.33	1.64

* 0 - No weeds, 10-100% weed coverage
** 0 - No injury 5 - dead

Results and Discussion

The plots were examined for weed prevalence and crop injury on August 12. The data from the sprayed treatments are listed in Table 1 and that of the granular applications in Table 2.

Good weed control was observed in plots sprayed with the following herbicides at the listed rates: dichlobenil at 4 and 8 pounds per acre, dacthal at 4, 8 and 16 pounds per acre, diphenamid at 8 pounds per acre, diuron at 1, 2, and 4 pounds per acre, tenoran at 2, 4, and 8 pounds per acre, trifluralin at 2, 4, and 8 pounds per acre, and TH-052H at 4 and 8 pounds per acre. Some injury on the scarlet sage was noticed in the following treatments: dacthal at 8 pounds per acre, tenoran at 8 pounds per acre, and trifluralin at 8 pounds per acre.

Fewer of the granular herbicide treated plots exhibited good weed control. Those that did were dichlobenil at 4 and 8 pounds per acre, diuron at 2 and 4 pounds per acre, and trifluralin at 4 and 8 pounds per acre. Scarlet sage plants showed some injury in granular herbicide treated plots in the following treatments: dichlobenil at 2, 4, and 8 pounds per acre, EPTC at 8 pounds per acre, and vernam at 8 pounds per acre.

In general plots treated with a herbicide at a given rate of application tended to exhibit better weed control when sprayed on than when applied in a granular form.

In the check plots, the principal weeds were yellow foxtail, redroot pigweed, lambsquarter, and tumble pigweed. Other weeds included Pennsylvania smartweed, common purslane, wild buckwheat, Canada thistle, field pepperweed, shepherdspurse, wild carrot, common ragweed, petunia, large crabgrass, common knotweed, whitlowwort, and yellow woodsorrel.

Summary

Seven granular herbicides and seven herbicide sprays were applied to scarlet sage plantings at three concentrations. All seven of the sprayed herbicides and two of the granular herbicides at one or more rates of application gave good weed control with little or no injury to the scarlet sage plants.

EFFECT OF HERBICIDES AND MULCHES ON SMALL NURSERY PLANTS

R. D. Fitzgerald & J. R. Havis[1]

There is a need for safe, effective and dependable weed control for a wide range of plant species of liner size.

Many nurserymen wish to use organic mulch for beneficial effects such as moisture retention and maintaining soil structure. Previous work (1) showed that two inches of mulch controlled weeds to about the same degree as 8 pounds per acre of CIPC, but neither of the treatments provided the degree of control that might be desired.

The purpose of this experiment was to learn if mulches and herbicides might produce additive effects that would be greatly superior to either treatment alone.

Materials and Methods

Two nursery beds were constructed in Paxton sandy loam at the Northeast Regional Extension Nursery Trial Area, Hathorne, Massachusetts. Well rotted manure was rototilled into the beds to insure a good supply of weeds. The beds were divided into twelve equal plots. This allowed for three replications and four treatments. The plots were further divided into three sections for sugar cane mulch, shredded bark mulch and no mulch.

Rooted cuttings of lilac, Ludwig Spaeth, rhododendron seedlings, azalea poukhanense (3 yr. old transplants) and Euonymus fortunei, Emerald Cushion (3 yr. old transplants) were planted in rows May 20, 1964. Granular herbicides (listed in Table I) were applied by hand and treatments were mulched to a depth of one inch on May 20, 1964. Sugar cane mulch was the type commonly sold as poultry litter. Shredded bark was a product from log de-barking process in sawmill operations.

A brief shower (less than .2 inch) occurred after treatment. Supplemental irrigation was applied May 29, 1964 (.75 inch) and June 6, 1964 (1.0 inch).

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Results and Discussion

Weed control ratings were made July 17, 1964 and August 15, 1964 and the results are summarized in Table I. Predominate weeds were red root pigweed, lambs quarter, crabgrass and foxtail.

On July 17, all of the combinations of herbicides and mulches gave good weed control. The mulches without herbicides gave some, but inadequate, weed control. Dichlobenil was the only herbicide that gave satisfactory weed control when used without mulch.

It was thought that a mulch covering, by moderating the environment at the soil surface, could extend the effective period of weed control of a herbicide like CIPC. If this had occurred, the chemical under a mulch would have given weed control well beyond the time at which the chemical without mulch had lost its effect. This did not happen with CIPC, as can be seen in Table I, since the August weed control ratings for CIPC with both mulch materials are about the same as the ratings for the mulch materials without herbicide.

Similar comparisons can be made in Table I with the other two herbicides. At the August rating, dichlobenil greatly improved weed control over the mulches alone, but not over the herbicides without mulch. This indicates that conditions other than those produced by the mulches were favorable for a long period of effective weed control with the chemical. Simazine showed a benefit from being under the mulches when compared in August with mulches alone and with simazine alone.

No significant injury to any of the species was observed.

Summary

1. An evaluation of three granular herbicides in combination with two mulches was made in nursery bed plantings of azalea, rhododendron, euonymus and lilac.
2. Dichlobenil controlled broadleaved weeds better than simazine or CIPC, but appeared to be weak against annual grass weeds.
3. Simazine and CIPC at the rates used, failed to give satisfactory weed control.
4. Mulches greatly improved the control of weeds by herbicides and the effects appeared to be additive.
5. Little or no plant injury was observed on any of the plant species.

Literature Cited

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Table I Control of Annual Weeds in Nursery Beds
from Applications made May 20, 1964

Treatment	ai lbs/A	Weed Control 1/ 7/17/64						Weed Control 1/ 8/15/64					
		Sugar Cane		Bark		No Mulch		Sugar Cane		Bark		No Mulc	
		Grass	B. L.	Grass	B. L.	Grass	B. L.	Grass	B. L.	Grass	B. L.	Grass	B
Simazine Gr	1.5	7.6	7.3	8.0	7.3	6.0	5.3	6.3	5.0	6.0	5.3	3.3	
CIPC Gr	8	7.3	7.3	7.3	7.0	6.0	5.6	5.0	4.0	4.3	3.3	2.3	
Dichlobenil Gr	3	8.6	9.0	8.6	9.0	7.3	8.3	7.6	9.0	7.3	8.6	6.6	
Check	-	6.0	5.0	5.6	5.5	2.0	1.0	4.3	2.6	3.3	3.0	1.0	

1/ Weed Control 1 = No Control, 9 = Excellent Control, 7 = Acceptable Comme
Control

The Use of Herbicides With Mulches

Arthur Bing[1]

The use of herbicides to control weeds in commercial nurseries is becoming accepted practice. The use of sound weed control practices in landscape plantings adjacent to commercial buildings and roadsides has not received adequate attention. There are several differences in the problems involved. In nurseries usually there are blocks of similar plants grown in rows on relatively level land accessible to machinery for cultivation or for herbicidal treatments. The landscaped areas often contain a wide variety of closely spaced plants on a more or less steep slope which is usually not accessible to machinery for cultivation. The fill used in areas to be landscaped also can contain a wide variety of persistent weeds.

On public highway jobs the landscape contractor must maintain the plantings for one year before the state inspectors inventory the plants for payment. Often it is necessary to hand weed the areas to find the plants: this is costly. Herbicides may control weeds but increase the erosion problem. The herbicide may wash down with the soil causing the destruction of lawn areas down hill from treated shrub plantings. Mulch materials have been used to control weeds but the thick layers needed are costly and do not control some of the larger growing weeds. Some mulch materials are difficult to apply and some are a fire hazard. Black plastic mulch has been used effectively but is difficult to apply. Pridham finds black polyethylene mulch still effective after 6 years in place. Large weeds grow in the openings and must be removed by hand.

We became interested in the use of combinations of mulch materials and herbicides that would control weeds effectively, be safe to landscape plants, prevent erosion and also be inexpensive.

Methods and Materials

The effectiveness of the herbicide and mulch combinations was tested on nursery rows of a limited number of test plants. The plants were at 2 ft intervals in rows 3 ft apart with treatments made across the rows. Plants were cultivated once and then irrigated to settle the soil before treatments. Only small liners were used in these tests because they would be more sensitive to herbicides. Weed counts were made periodically the first year and the growth of crop plants was rated for a 3 year period. Plants were cultivated the second and third growing seasons to facilitate observation of the plants.

The various rates of granular herbicide were applied with a calibrated lawn fertilizer spreader in 1962 and 1963 and with a precision augur feed granular applicator in 1964. Liquid applications were made with 1½ gal hand pumped pressure sprayers. Herbicides were applied on bare soil, on bare soil followed by a covering of mulch, or incorporated in the mulch before application to the soil surface. Mulches were applied by hand except the cellulose fiber in 1964 which was applied with a "Hydro Seeder". No attempt was made to use all available mulches or herbicides: a limited number of readily available mulches and longer lasting herbicides was used and they are shown in Tables 1 and 2.

Dry mulch materials were mixed with herbicides before application by putting the mulch in a concrete mixer and spraying in the proper amount of herbicide in water as the mulch was tumbling in the mixer. Some of the asphalt emulsion from Esso Oil Company was prepared by them to contain the herbicides in the

maximum rate we would use. They also supplied plain asphalt emulsion which we used to dilute the concentrate to desired levels.

The untreated and treated mulches were applied at various rates to determine the minimum amount of mulch required to give satisfactory results.

Irrigation was applied as necessary by use of rain bird nozzles on risers from portable aluminum pipe.

Discussion of Results

There were some general observations made on the handling of the mulch materials used in these experiments. All materials were effective for weed control when used with sufficient herbicide. Without the herbicide some mulches did not adequately control weeds, others would control weeds only if used in applications of 2-3 in.

The asphalt emulsion was about as effective with simazine or diuron incorporated in the emulsion as when used to cover the herbicide treated soil. It was necessary to use the asphalt at a rate of 600 gpa to get adequate coverage. The asphalt sprayed on the plants did not injure them seriously as the new growth was normal. The black coating would be expected to reduce the photosynthesis in covered leaves. A directional spray was difficult with small plants but would be necessary for best results. The asphalt coatings on the soil lasted most of the 1962 and 1963 growing seasons but by the following spring each was fairly well disintegrated. The asphalt can be sloppy to handle. In 1963 after the experience of 1962 the treatments went on much easier. Asphalt alone even at rates of 1200 gpa was not satisfactory for controlling weeds. The asphalt covering on a short 20° slope prevented erosion. The asphalt was sprayed on a flat of soil which was then put at a 20° angle and periodically sprayed with water.

The cocoa hulls were easy to apply as they come in bags and pour easily. A ½ in layer with dichlobenil or simazine was very effective. A layer of 1½ to 2 in without herbicide gave good weed control. Conceivably, wind may blow the dry hulls away from the plants but this was not much of a problem even though the treated areas were in an open area exposed to high winds. After 1 season's growth no adverse effects were noted.

Licorice root is the remains after licorice roots are steamed to extract the licorice. It is considerably heavier than most of the other mulch materials and was not moved by wind. It was only used in ½, 1½ and 2 in layers plain and ½ over herbicide. The ½ in over dichlobenil was much better than any thickness of the mulch itself. It was not affected by adverse weather conditions and persisted to the second growing season. When on a short 20° slope it was not eroded by water.

Coarse sphagnum peat moss with herbicide or over herbicide should be at least ½ in thick. The fine grades when dry are easily blown away. A medium coarse lumpy grade stays in place and can be reasonably uniformly spread. Treated peat held over in plastic bags to the next year was still effective in controlling weeds. The peat also improves the soil if incorporated after its herbicidal usefulness is terminated. The fine grades were easily eroded by water on a short 20° slope.

The paraffin emulsion did not change the appearance of the soil. It was

When used over herbicide the treatment was about equal to herbicide alone.

The salt hay was used over dichlobenil and simazine treatments in 1964. It was applied by hand in a thin layer for soil stabilization and was quite effective. Machinery is available for applying chopped hay mulch to large areas.

The cellulose fiber was applied by hand in 1963 and with the "Hydro Seeder" in 1964. The material is uniform, easy to apply by machine, can be mixed with herbicide in the spray tank before application and is well agitated in the spray tank to give uniform coverage. The fiber mulch is persistent for 2 seasons. The fiber is colored green but soon bleaches to a light gray. It persisted on a 20° slope when exposed to flowing water.

In 1962 herbicides under mulches and incorporated with mulches gave comparable results; consequently in most of the 1963 and 1964 treatments the herbicides were incorporated with the mulches.

Rates of chemicals used alone or in combination with mulches and the minimum rate to give adequate weed control are shown in Tables 5 and 7. Weed ratings are from 1 with no weeds to 10 solid with weeds. Ratings of 3 or 4 would be adequate for commercial control. Individual weed counts as to species were made but the results are not incorporated in this report. Herbicide rates used in 1964 were based on the results of previous years. The better results in 1964 were probably due to better moisture control. All treatments gave very good weed control in 1964.

Crop tolerances for some of the 1963 and 1964 treatments are shown in Tables 6 and 8. Observation the first season usually shows a high degree of tolerance for the herbicides with the second year data occasionally showing reduced tolerance. Taxus, Ilex and Juniperus are tolerant to fairly high rates of simazine, dichlobenil, and diuron. Azaleas are quite sensitive to most of the herbicide treatments. Although the azalea plants show few signs of injury the first fall, by the following spring there are often few survivors. In Table 8 under azalea simazine treatment the 4/0 indicates no injury with 4 lb simazine aia in the fall of 1963 but even the adjacent untreated azalea plants were dead by the next fall. The tolerance the first season of azaleas treated with peat treated with simazine 10 lb aia was good but by the next season there were no survivors.

The combinations of mulches and herbicides were very effective. In 1962 and 1963 dichlobenil with mulch was much more effective than when used alone probably because the dichlobenil is more easily lost to the air by vaporization when not covered by a mulch. Table 7 under dichlobenil shows it took 10 lb aia to give the same weed control as 3 lb aia when incorporated with peat. The diuron and simazine did not show this marked difference. Further studies using other mulches and the effect of water on mulches applied to slopes are planned along with larger scale treatments on roadside and landscape plantings.

Table 1. Mulch materials used.

Material	Year used 1962	1963	1964
Asphalt emulsion	x	x	
Black polyethylene			x
Cocoa hulls			x
Licorice root		x	
Paraffin emulsion	x		
Sphagnum peat moss	x	x	x
Cellulose fibre		x	x
Black polyethylene on paper			x
Salt hay			x

Table 2. Herbicides used.

Chemical name	Common name	Year used 1962	1963	1964
2,6-dichlorobenzonitrile	dichlobenil		x	x
3-(3,4-dichlorophenyl)-1,1 dimethyl urea	diuron	x	x	x
3-(3,4-dichlorophenyl)-1 methoxy-1-methylurea	linuron	x		
2-chloro-4,6-bis (ethylamino)-s-triazine	simazine	x	x	x

Table 3. Plants used.

Scientific name	Common name	Year used 1962	1963	1964
Euomymus fortunei	Euomymus	x		
Ilex crenata convexa	Boxleafed holly		x	x
Juniperus chinenses Hetzii glauca	Hetz juniper		x	
Ligustrum ovalifolium	Privet	x		
Pinus thunbergii	Japanese black pine			x
Rhododendron obtusum var. Hinodegiri	Azalea	x	x	x
Taxus media Hicksii	Hicks yew	x	x	x

Table 4. Weeds common to the test area.

Scientific name	Common name
Amaranthus retroflexus	Red root
Chenepodium album	Common lambsquarters
Digitaria ischaemum	Crabgrass
Echinochloa crusgalli	Barnyard grass
Galinsoga parviflora	Small flower galinsoga
Mollugo verticillata	Carpetweed
Oxalis stricta	Yellow woodsorrell
Senecio vulgaris	Common groundsel
Setaria glauca	Yellow foxtail grass
Stellaria media	Chickweed

Table 5. Weed control ratings 1964 mulch plots.

Treatment	Rates used lb aia	Minimum rate for commercial** weed control	Actual weed control rating*
Dichlobenil L***	6,8,10	6	2
Dichlobenil G	7,9,10	10	2
Dichlobenil L under cocoa hulls	6,8,10	6	1
Dichlobenil L incorporated with cocoa hulls	6,8,10	6	2
Dichlobenil L under salt hay	6,8,10	6	1
Dichlobenil L incorporated with Turfibre	6		
Simazine L	2,4,6,8	2	1
Simazine L under salt hay	4,6,8	4	1
Simazine G	6,8,10	6	2
Simazine L under cocoa hulls	4,6,8	4	1
Simazine L incorporated with cocoa hulls	4,6,8,10	4	2
Simazine L incorporated with Turfibre	4,6,8	4	3
Untreated			10
Cocoa hulls	½",1",1½"	1"	2

* 1= no weeds, 10= full of weeds: ratings made Sept. 15, 1964
** 3-4= commercial weed control
*** L= liquid, G= granular

Table 6. Plant stand 1964 mulch plot treatments.

Treatment	Highest rate at which plant stand rated 2* or better lb herbicide aia for Yew	Ilex	Azalea	Pine**
Dichlobenil L***	10+	10+	10+	10+
Dichlobenil G	10+	10+	10+	10+
Dichlobenil L under cocoa hulls	10+	10+	10+	6-
Dichlobenil L incorporated with cocoa hulls	10+	10+	10+	6-
Dichlobenil L under salt hay	10+	10+	10+	10+
Dichlobenil L incorporated with Turfibre	6+	6+	6+	6+
Simazine L	8+	8+	8+	8+
Simazine G	8+	8+	8+	8+
Simazine L under cocoa hulls	8+	8+	8+	8+
Simazine L incorporated with cocoa hulls	8+	8+	8+	8+
Simazine L under salt hay	8+	8+	8+	6
Simazine L incorporated with Turfibre	8+	8	8	8

* Plant stand: 1+ = excellent growth, 2= good growth, 3= fair growth, 4= poor growth, 5= dead plants
** + indicates highest rate used caused no injury by Oct. 1964
- indicates injury at lowest rate used
*** L = liquid, G = granular. See Table 5 for rates used.

Table 7. Weed control ratings 1963 mulch plots.

Treatment	Rates used lb aia	Minimum rate for commercial** weed control	Actual weed control rating*
Dichlobenil L***	1,2,4,6,8,10	10	2
Dichlobenil L incorporated with peat	3,6,9	3	2
Dichlobenil L incorporated with asphalt	1,2,4,6,8,10	10	3
Dichlobenil L under licorice root	6	6	3
Dichlobenil L under Turfibre	6	6	1
Simazine L	1,2,4,6,8,10		2
Simazine L incorporated with peat	1,2,4,6,8,10	6	4
Simazine L incorporated with asphalt	1,2,4,6,8,10	4	3
Diuron L	1,2,3,5	3	2
Diuron L incorporated with peat	1,2,3,5	2	2
Diuron L incorporated with asphalt	1,2,3,5	2	2
Untreated			10

* 1= no weeds, 10= full of weeds: ratings made Sept. 6-10, 1963
** 3-4 = commercial weed control
*** L = liquid, G = granular

Table 8. Plant stand 1963 mulch plots rated October 1963 and November 1964.

Treatment	Highest rate at which plant stand rated 2* or better lb herbicide aia for			
	Yew	Azalea	Ilex	Juniper
Dichlobenil L***	10+	10+/2-**	10+	10+
Dichlobenil L incorporated with peat	9+	9+/0	9+	9+
Dichlobenil L incorporated with asphalt	10/	8/	10+/	10+/
Dichlobenil L under licorice root	6+	6+	6+	6+
Dichlobenil L under Turfibre	6+	6+	6+	6+
Simazine L	10+	4/0	10+/6	10+
Simazine L incorporated with peat	10+	10+/0	10+	10+
Simazine L incorporated with asphalt	10+	0	10+	10+
Diuron L	5+	1-	5+	5+
Diuron L incorporated with peat	5+	5+/0	5+/2	5+/4
Diuron L incorporated with asphalt	5+/3	1/0	5+	5+

* Plant stand: 1+ = excellent growth, 2= good growth, 3= fair growth, 4= poor growth, 5= dead plants.
** 1963/1964 ratings if they differ 0=adjacent untreated also dead
*** L = liquid, G = granular, see Table 7 for rates used.

Acknowledgments

The following is a list of materials used in these experiments and the suppliers: dichlobenil (Casoron) by Thompson Hayward, diuron (Karmex DW) and linuron (Lorox) by DuPont, simazine by Geigy, asphalt emulsion by Esso Research and Engineering, black polyethylene film by DuPont, cocoa hulls by Hershey Estates, paraffin emulsion by Sun Oil Co., sphagnum peat moss by Premier Peat, cellulose fibre (Turfibre) by International Paper, and black polyethylene on kraft paper by St. Regis Paper.

EFFECT OF YEARLY FALL BANDING OF TAXUS MEDIA HICKSII AND OTHER EVERGREENS WITH GRANULAR HERBICIDES AT EFFECTIVE LEVELS FOR SEEDLING WEED CONTROL

A. M. S. Pridham[1]

Taxus media hicksii and many other evergreens remain for 3 or more years in one field before removal for sale or for growing on to a larger size. Weed control includes cultivation, hoeing, as well as the use of herbicides.

In the present case plants of three evergreens (Thuja occidentalis var. George Peabody, Juniperus chinensis hetzi and Taxus media hicksii) were planted in September 1959. The soil was rototilled and worked during early August and planting of 18" plants from #10 containers was completed by mid September. Rows were 150' long with plants at 3' intervals. Herbicides were applied with a modified fertilizer spreader 2' wide and raised by 35" diameter wheels to clear the plants. Treatments were made once each year in October or early November, i.e. when germination and growth of winter weeds begins. No further cultivation or herbicide application was made till June to July. Space between plant rows was rototilled. Cross rototilling was also done so that hoeing was limited to the 12-18" square of soil containing the Taxus or other nursery stock. Summer weeds included lambsquarters and summer grasses, also quackgrass. Two or three cultivations were made between June and October. The location of this planting is McGowan Field.

In 1964 soil samples were collected from twenty 150' rows at two stations in each row. Soil was removed from the surface ½" in the undisturbed block adjacent to the plant. The second sample was taken from the 1-3" level and a third sample from the 3-6" level.

Two samples of 2 lbs. each were placed in plastic "Market Pac" trays and planted to garden beans (10) and to oats, thus six samples were used from each sampling station. There were four field treated rows for each herbicide and for the untreated check rows.

The influence of continued use of the specific herbicides C.I.P.C., dichlorobenil (Casoron), D.N.B.P. (Dinitro), and Diuron, was estimated on the basis of 1) number of beans growing, 2) mean height of 8 cultures, 3) mean green weight of bean plants. Based on the performance of the population of the untreated control plants, values are suggested indicating the magnitude of the difference necessary for significance at the 1% level (see Table 1).

Differences other than survival, mean height and weight per plant were not obvious. Growth of oats was normal in color and habit. The nursery crops in the field did not show color differences except one Taxus plant in the Diuron treatment. This plant had a discolored shoot in 1964.

Amizine was used in July 1963 and again in 1964 as a foliar spray on quackgrass, chiefly on the space between plant rows. This spot treatment was of 2 lbs. aia. Simazine content per 100 gallons of spray per acre; essentially to moisten young quackgrass foliage to run off. Young quackgrass foliage did respond to Amizine treatment. The spray was applied directionally to reduce contact with crop foliage, and no case of discoloration was noted.

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Plots in similar soil but different fields (East Ithaca) contained similar evergreens and received Amizine and Simazine yearly for four years. Fall applications were made directionally for Amizine and overall as a granular for Simazine, CIPC, and Diuron. Soil samples were taken in fall 1964 and cultures set up as noted above.

The broadcasting of herbicide over the total plot area rather than confining it to approximately 1/3 of the area may increase the amount of herbicide in the surface soil samples since growth in number, height and weight of beans in soil samples from below the surface compares favorably with that in control or untreated check samples, i.e. sample taken from larger area than 12x12".

Bean samples in two Simazine and one Amizine plot had one or more juvenile leaves with gray (1) and yellow blotched areas indicative of Triazine injury. Juvenile foliage and some mature foliage of beans planted in McGowan soil to which granular Simazine was added to the soil sample at 6 lbs. aia level had characteristic graying, followed by yellow blotching, wilting and death of most of the juvenile and some newly developed trifoliate leaves. Thus band treatment would be preferred and minimum rates encouraged.

Table 1. Response of garden beans planted in soils receiving yearly band applications of herbicide in autumn. Response expressed as 1) mean number of plants from 10 seeds, 2) mean height (inches) per plant, and 3) mean weight in grams per plant from eight replicates under greenhouse conditions and intermittent misting.

Herbicide and rate aia		Top ½" soil			3-6" soil			6-9" soil		
		No.	Ht. inches	Wt. gr.	No.	Ht. inches	Wt. gr.	No.	Ht. inches	Wt. gr.
McGowan Field, 30 days										
CIPC	8	9.3	12.6	3.2	8.6	13.2	3.1	7.5	12.1	2.6
Dichlobenil	10	8.4	12.1	3.2	8.2	13.6	2.8	8.8	12.1	2.9
Diuron	2	9.2	10.9	2.9	8.0	12.1	2.7	9.3	12.8	2.8
D.N.B.P.	4	8.6	12.4	3.0	9.6	12.5	2.9	9.3	13.1	3.0
Untreated		9.9	13.4	3.1	9.2	13.3	3.0	9.4	14.0	3.0
D odds 1%		1.9	4.9	1.6	3.1	6.3	1.6	2.4	9.3	0.2
East Ithaca, 25 days										
Amizine	2 (5)	5.4	8.3	3.0	6.6	9.1	3.3	6.6	9.1	3.1
CIPC	8 (2)	5.0	8.9	3.0	8.0	9.6	3.2	8.0	10.3	3.2
Diuron	2 (3)	5.3	6.2	2.7	7.7	7.3	2.7	8.3	8.6	2.9
Simazine	2 (5)	2.5	7.2	3.0	2.4	8.5	3.6	6.2	9.9	3.3
Untreated	0 (1)	7.0	11.0	3.4	9.0	7.6	2.3	7.0	10.5	3.0

Number of plants per culture, 8 replicates, crop - garden beans
Height of plants inches
Weight of plant in grams, 10 seeds planted

(1) Pridham, A. M. S. 1963. Residual effect of herbicides on growth of ornamentals. Proc. N.E.W.C.C., Vol. 17, p. 218-220.

SEASONAL WEED CONTROL IN ANNUAL FLOWERS

Chiko Haramaki[1]

Home gardeners as well as commercial flower growers and seedsmen have expressed their difficulty in maintaining weed-free flower beds. Past studies have indicated that this probably could be best achieved by the use of soil-incorporated, pre-transplant herbicide treatments. The objectives of this experiment were to determine which pre-transplant herbicide treatments would give the best weed control with the least injury to the transplanted annual flowers.

Methods

The soil was plowed, disced and rototilled several times prior to treatment. On July 1, 1964, the soil was treated with either granular or liquid forms of several herbicides. Each plot was rototilled immediately after the herbicide application. The silt loam soil at the time of treatment had temperatures of 97° F. and 76° F., one inch and six inches respectively below the soil line. The soil was powder dry and the air temperature was 90° F. in the shade.

Each herbicide treatment plot was 300 square feet and replicated three times. Granular and spray formulations of four herbicides and two spraying rates of another herbicide plus a check were used.

Eight days later, on July 9, 1964, the annual flowers were transplanted and an inch of water was applied.

Results and Discussion

On August 10, 1964, which was six weeks after treatment, the plots were examined for weed prevalence and for crop injury. The data on weed prevalence are summarized in Table 1, while the data on crop injury are summarized in Table 2.

Excellent weed control was observed in plots treated with dichlobenil at 2 pounds per acre with either the wettable powder or granular formulations. Excellent weed control was also obtained with the emulsifiable concentrate and granular formulations of EPTC, and vernam at 7 1/2 pounds per acre and trifluralin at 2 pounds per acre. Dacthal at 5 and 10 pounds per acre gave fair to poor weed control when incorporated in the soil.

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Table 1. Prevalence of weeds in flower beds, 6 weeks after treatment, 1964

Herbicide	Weed Prevalence*	Weeds Present in Decreasing Order of Frequency
Check	9.33	Tumble pigweed, redroot pigweed, yellow foxtail, common lambsquarter, Canada thistle, Pa. smartweed
EPTC, G. - 7 1/2 #/A	0.00	Redroot pigweed, tumble pigweed, Canada thistle, wild carrot, wild buckwheat, field pepperweed
Trifluralin, EC - 2 #/A	0.00	Field pepperweed, Canada thistle, wild carrot, redroot pigweed, tumble pigweed, common ragweed
Vernam, EC - 7 1/2 #/A	0.00	Canada thistle, redroot pigweed, tumble pigweed, common ragweed, Pa. smartweed, yellow foxtail
Vernam, G. - 7 1/2 #/A	0.00	Canada thistle, common ragweed, tumble pigweed, yellow foxtail, Pa. smartweed, redroot pigweed
EPTC, EC - 7 1/2 #/A	0.33	Canada thistle, tumble pigweed, redroot pigweed, common purslane, common ragweed, annual fleabane
Dichlobenil, WP - 2 #/A	0.33	Yellow foxtail, tumble pigweed, redroot pigweed, large crabgrass, Canada thistle, common purslane
Trifluralin, G. - 2 #/A	0.67	Canada thistle, field pepperweed, tumble pigweed, Pa. smartweed, Whitlowwort, wild carrot
Dichlobenil, G. - 2 #/A	1.00	Yellow foxtail, tumble pigweed, redroot pigweed, Pa. smartweed, common lambsquarter, field pepperweed
Dacthal, WP - 5 #/A	2.00	Tumble pigweed, redroot pigweed, common lambsquarter, yellow foxtail, Pa. smartweed, field pepperweed
Dacthal, WP - 10 #/A	5.67	Tumble pigweed, redroot pigweed, yellow foxtail, Pa. smartweed, field pepperweed, common lambsquarter

* 0 - None to 5% weed coverage
10 - 100% weed coverage

Table 2. Effect of pre-transplant herbicides on annual flowers which were transplanted 8 days after treatment. 1964

Herbicide	American Marigold	Aster	Impatiens	Petunia	Portulaca	Scarlet Sage	Snap-dragon	Zinnia
Check	0.22	1.58	0.73	0.53	0.67	0.39	0.02	0.17
Dacthal, WP 5 #/A	0.28	1.99	0.82	0.18	0.50	0.46	0.08	0.46
Dacthal, WP 10 #/A	0.14	1.42	1.18	0.11	1.50	0.33	0.23	0.50
Dichlobenil, WP 2 #/A	1.03	1.90	1.27	0.14	1.58	1.42	2.38	0.75
Dichlobenil, G 2 #/A	1.22	1.69	1.55	0.58	1.33	1.71	2.94	1.00
EPTC, E.C. 7½ #/A	0.14	1.55	1.09	0.36	0.50	3.96	1.81	0.17
EPTC, G 7½ #/A	0.31	1.57	1.91	0.46	1.78	3.83	2.33	0.54
Trifluralin, E.C. 2#/A	0.08	1.49	0.64	0.31	2.17	0.25	0.23	0.25
Trifluralin, G 2 #/A	0.11	0.89	0.45	0.69	1.92	0.00	0.13	0.13
Vernam, E.C. 7½ #/A	0.19	1.47	2.64	0.25	1.75	3.71	2.10	0.58
Vernam, G 7½ #/A	0.11	1.45	2.45	0.47	1.83	3.33	1.27	0.29

0 - No injury, 5 - Dead

The principal weeds in the check plots were tumble pigweed, redroot pigweed, yellow foxtail, common lambsquarter, Canada thistle and Pennsylvania smartweed. Less frequent weeds included wild buckwheat, common purslane, field pepperweed, whitlowwort, wild carrot, large crabgrass, and common ragweed.

American marigold plants exhibited poor to good growth and flowering, also chlorosis, purpling, necrosis and abscission of some of the lower foliage in the dichlobenil treated plots. Some chlorosis and abscission of the lower foliage was noted in the granular EPTC treated plots. The marigolds showed good growth and flowering in the other treatments.

Aster plants in all treatments including the check were partially affected by wilt. A few plants in all treated plots showed some chlorosis in the lower leaves. The asters in general showed good growth and flowering.

Impatiens plants had poor to fairly good growth and flowering in dichlobenil and EPTC treated plots. In vernam treated plots the impatiens had poor to fair growth with few or no flowers. The other treatments exhibited little or no injury.

Petunia plants exhibited little or no injury in any of the plots.

Portulaca plants showed poor to fairly good growth with some defoliation in the plots treated with dacthal at 10 pounds per acre, dichlobenil, and trifluralin. In EPTC and vernam treated plots the leaves tended to be stubby and appressed to the stem. The other plots had good growth and flowering.

Scarlet sage plants exhibited poor to fairly good growth and flowering in dichlobenil treated plots. They were severely injured in the EPTC and vernam treated plots. The plants were defoliated in most cases with the remaining leaves exhibiting blackened leaf tips, edges and interveinal areas. The scarlet sage plants tended to die back from the shoot terminals. All of the buds were also dead. The other treatments had little or no effect on the scarlet sage.

Snapdragon plants in dichlobenil treated plots showed poor to fairly good growth and flowering. Most of the plants showed some chlorosis, necrosis or were dead. In the EPTC and vernam treated plots the plants had fairly good growth and flowering but the leaves of the axillary buds were badly distorted.

Zinnia plants in all plots had good vegetative growth and flowering but some distortion was noticed on the new leaves of plants growing in the dichlobenil, EPTC and vernam treated plots.

The trifluralin treatments gave excellent weed control with the least injury to the eight annual flowers tested except for portulaca.

Summary

Five pre-transplant herbicides either in liquid or granular form were incorporated in the soil. Eight different annual flower species were transplanted in these beds.

Excellent weed control was obtained with the use of EPTC and vernam at 7 1/2 pounds per acre, and dichlobenil and trifluralin at 2 pounds per acre. A few of the annual flower species tested showed some injury to dichlobenil, EPTC and vernam at the rates used. Annual flower plants other than portulaca had good vegetative growth and flowering in trifluralin treated plots.

EFFECTS OF HERBICIDES AND SOIL NITROGEN LEVELS ON SPRING SEEDINGS OF ALFALFA[1]

J. O. Pearson and R. C. Wakefield[2]

Introduction

The use of herbicides for controlling weeds in seedings of alfalfa is increasing and giving relatively weed-free forages during the seeding year (1)(2)(3). Although late summer plantings may be more advantageous in order to avoid serious weed competition, many seedings are still made in the spring. Competition between alfalfa and weeds is increased by applications of nitrogen (2) and for this reason nitrogen fertilization is not a common practice although nitrogen applications may be desirable if weeds are controlled. There is some evidence that nitrogen may influence the effectiveness of certain herbicides (4) in newly established alfalfa. This study was designed to investigate the interrelationship of herbicides and soil nitrogen levels in spring seedings of alfalfa.

Procedure

A weed control experiment was established on the university agronomy plots on May 8, 1964 in an area selected for its known heavy weed infestation. Four replications were used in a randomized split plot design with individual plot size being 6x20 feet.

Nitrogen was applied to the main plots at rates of 0, 25 and 50 lb per acre. Fertilizer was broadcast over the whole area to provide 175 lb of P_2O_5 and 175 lb of K_2O per acre. Narragansett alfalfa was seeded at 15 lb per acre.

Herbicides were applied to randomly selected sub-plots in 30 gallons of water per acre using a bicycle-type compressed air sprayer. Chemicals are listed in the Appendix. Eptam and treflan were incorporated into the soil by roto-tilling the materials about two inches into the soil. The time and rates of application were as follows:

a. Incorporated - May 8
   Eptam 4 lb (ai)/acre
   Treflan 1 lb (ai)/acre

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[2]Graduate Assistant and Associate Professor, respectively, Department of Agronomy and Mechanized Agriculture.

b. Postemergence - June 11
4(2,4-DB) amine 3/4 lb (ai)/acre
4(2,4-DB) ester 3/4 lb (ai)/acre
4(2,4-DB) amine + dalapon 1½ lb (ai)/acre

A 3x16 feet strip was harvested from each plot for yield determinations on July 21, 1964. A second harvest was not made due to variability introduced by drought conditions. Botanical composition was determined by hand separations of sub-samples. Alfalfa plant counts and root-crown weights were determined from plants dug from a one-square-foot area on October 6. The plants were then counted and the roots clipped to six inches before drying and weighing.

Results and Discussion

Rainfall

Soil moisture at the time of seeding was adequate for complete germination although the rainfall for May was 2.82 inches below normal. June rainfall was only 0.86 inches or 2.20 inches below normal. Growth was retarded considerably on the dry Bridgehampton silt loam due to these droughty months. The test area was irrigated with about one inch of water on June 30 to help alleviate the dry conditions. Additional droughty conditions in July and August further retarded regrowth of alfalfa and prevented taking a second harvest.

Weed Populations

The area selected for this experiment had a heavy infestation of pigweed (*Amaranthus retroflexus*), ragweed (*Ambrosia artemisiifolia*), lambsquarters (*Chenopodium album*), and a few annual grasses mostly yellow foxtail (*Setaria glauca*). The weeds were well distributed within replicates with the exception of nutgrass (*Cyperus esculentus*).

Herbicidal Effects

Yields of alfalfa, broadleaved and grass weeds and alfalfa plant counts are presented in Table 1. Root weights were not significantly different and are not included.

All treatments produced significantly more alfalfa than the unsprayed check plots with Eptam giving the highest yields. There were no differences among the remaining treatments. Nitrogen had no significant influence on the yield of alfalfa.

All herbicides effectively controlled all broadleaved weeds. On the average there was no difference among the herbicides in the control of these weeds. The interaction of treflan with the high rate of nitrogen did

Table 1. Average yields of alfalfa, weeds and alfalfa plant counts affected by herbicides and soil nitrogen levels. Kingston, R.I. 1964.

Treatment			Yields - D.M. Tons/A			
Herbicide	lb/A a i	Nitrogen lb/A	Alfalfa	Broadleaved weeds	Grass weeds	Plants/ sq ft
1. 4(2,4-DB) amine	3/4	0	1.16 cdefg*	.06 d	.05 a	38.3 cde
		25	1.24 bcde	.11 d	.03 a	41.0 bc
		50	1.03 defg	.16 cd	.03 a	30.0 f
2. 4(2,4-DB) ester	3/4	0	1.27 bcde	.05 d	.04 a	37.8 cde
		25	1.05 defg	.09 d	.13 a	39.8 bcde
		50	1.17 cdef	.16 cd	.18 a	38.0 cde
3. 4(2,4-DB) amine + Dalapon	3/4	0	1.24 bcde	.09 d	.02 a	40.8 bc
		25	.99 efg	.10 d	.06 a	31.8 f
	1½	50	.99 efg	.17 cd	.04 a	31.8 f
4. Treflan	1	0	1.23 bcde	.10 d	.01 a	39.8 bcde
		25	1.31 bcd	.09 d	.02 a	45.3 a
		50	1.05 defg	.28 c	.01 a	36.3 de
5. Eptam	4	0	1.39 abc	.05 d	.02 a	42.8 ab
		25	1.59 a	.10 d	.00 a	40.5 bcd
		50	1.51 ab	.16 cd	.02 a	36.0 e
6. Check		0	1.11 cdefg	.17 cd	.07 a	41.3 bc
		25	.92 fgh	.45 b	.05 a	37.5 cde
		50	.66 h	.88 a	.09 a	38.5 cde
Averages						
4(2,4-DB) amine			1.14 b	.11 b	.04 bc	36.4 bc
" ester			1.16 b	.10 b	.12 a	38.5 ab
4(2,4-DB) amine + Dalapon			1.07 b	.12 b	.04 bc	34.8 c
Treflan			1.20 b	.15 b	.01 c	40.4 a
Eptam			1.50 a	.10 b	.01 c	39.8 a
Check			.90 c	.50 a	.07 b	39.1 a
		0	1.23 a	.09 b	.03 a	40.1 a
		25	1.18 a	.15 b	.05 a	39.3 a
		50	1.07 a	.30 a	.06 a	35.1 a

*Means followed by different letters are significantly different at the 5% level using the Duncan Multiple Range Test.

significantly decrease the control of broadleaved weeds. A reduction in control under high nitrogen can also be noted with other herbicides. It was noted that although weed control was good with all herbicides at all nitrogen levels, those weeds not controlled at high nitrogen levels were very large and healthy. This was particularly true with pigweed.

Control of grass-type weeds was significantly increased by both eptam and treflan on the average. Other treatments however had no significant effect on grass weeds. Nitrogen at high rates did not decrease the apparent effectiveness of herbicides as with broadleaved species. Nutgrass, which was unevenly distributed in the experimental area, was observed to be controlled very well with eptam.

The combination of 4(2,4-DB) amine and dalapon significantly decreased the number of alfalfa plants per square foot and tended to decrease the yield of alfalfa indicating possible injury. This was particularly evident with the 25 and 50 lb rates of nitrogen. A similar effect can be seen with 4(2,4-DB) amine used alone with high nitrogen. It is believed that the decrease in alfalfa yield was due mostly to the interaction of the herbicide with nitrogen rather than to competition. Excellent establishment of alfalfa occurred when either eptam or treflan were used as seen by the high number of plants per square foot.

Nitrogen Effects

On the average, soil nitrogen levels had no significant influence on yields of alfalfa although there was a tendency for yields to decrease as nitrogen levels increased. This decrease of alfalfa in proportion to nitrogen levels is believed to have resulted from increased competition from weeds.

Control of broadleaved weeds was significantly lowered on the average with the highest level of nitrogen. There was no difference between the 0 and 25 lb/acre rate of nitrogen. Nitrogen, then, tended to reduce the effectiveness of the herbicides on broadleaved weeds.

Nitrogen did not influence the control of grass weeds significantly.

On the average nitrogen had no effect on the number of alfalfa plants per square foot. The interaction, however, of high levels of nitrogen with 4(2,4-DB) amine, 4(2,4-DB) amine plus dalapon, and eptam significantly lowered the number of plants per square foot exhibiting the competition of alfalfa with broadleaved weeds or indicating injury to the alfalfa.

Summary

Herbicides were evaluated on a spring seeding of alfalfa fertilized with three levels of nitrogen.

In general high levels of nitrogen decreased the apparent effectiveness of herbicides on broadleaved weeds.

Weeds were effectively controlled with both the amine and ester formulations of 4(2,4-DB). The combination of 4(2,4-DB) and dalapon injured alfalfa particularly when high levels of nitrogen were used. Treflan at 1 lb/acre controlled annual broadleaved and grass weeds with no apparent injury to alfalfa. Eptam was particularly effective in controlling nutgrass as well as annual weeds.

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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 3/4 lb ai/gal. Chipman Chemical Co., Amchem Products.

2. 2,2-dichloropropionic acid, sodium salt 74% ai -- (Dalapon). Dow Chemical Co.

3. Ethyl n,n-di-n-propylthiolcarbamate (Eptam). 4 lb ai/gal. Stauffer Chemical Co.

4. 2,6-dinitro-N,N-di-n-propyl-a,a-trifluoro-p-toluidine -- (Treflan). 1 lb ai/gal. Eli Lilly and Co.

BROADLEAF WEED CONTROL IN ESTABLISHED TREFOIL

T. R. Flanagan and G. B. MacCollom[1]

We have shown here earlier (1) and elsewhere (2) that trefoil seed yields can be enhanced through the judicious use of herbicides. Much of this early work has dealt with grass suppression by means of dalapon. From tests with combinations of dalapon and several forms of 4(2,4-DB) it was concluded that rate and time of application were extremely important. Best yields of trefoil seed have been obtained from the dalapon-4(2,4-DB) combinations applied as early as possible in the spring after weeds have started growth but while the trefoil was still reasonably dormant. Optimum rates seemed to be about 3 lbs. dalapon plus 3/4 lb. 4(2,4-DB). Some trefoil injury has been noted, particularly with higher rates of ester formulations.

Certain weed species were noted to be resistant to the dalapon-butyric combinations. Accordingly, simazine was included in later tests. This herbicide appeared to be effective in controlling several of the mustards and field chickweed. Other problem weeds, in addition to quackgrass, included such broadleafed species as chicory (Chicorium intybus,L.), fleabane (Erigeron spp), rough-fruited or sulfer cinquefoil (Potentilla recta L.), kale (Raphanus raphanistrum), hairy vetch (Vicia sativa) and others; also alsike clover, considered a weed in trefoil seed fields.

This past season plots, which had been treated in 1963 with various dalapon-4(2,4-DB) combinations, and others treated with simazine, were studied for seed yields and for degree of control of the several weeds mentioned above. One set of treatments had been applied in early spring (Figure 1), others in mid-summer on trefoil stubble following harvest (Figure 2). The "bare" ground conditions at this time are optimum for ground equipment spray application and many weeds are present--some as stubble, others as new seedlings.

Additionally, limited trials with several other herbicides, as yet untried in trefoil seed field situations, were established (Table 3). These plots were applied on April 29, 1964, on Mansfield trefoil approximately 2 in. tall. Sprays were applied with a jeep-mounted boom rig with 20 gpA water. Treatments included a dimethylamine formulation of 4(2,4-DB), dicamba, simazine, diuron, diphenamid, dichlobenil and an experimental triazine, all at two rates (½ and 1 lb. ai/A) Observations were made periodically following treatment and at harvest replicated forage samples were collected. The various weed species were separated out by hand, and the dry weights of these and trefoil seed yields recorded. The proportions of quackgrass and of the total broadleaf weed fractions are shown in Figure 1 as percent compositions in relation to that same fraction of the unsprayed check plot. It should be noted that the treatments on these plots were

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applied 14 months previously, and what we were measuring represented to some degree residual effects. None of the seed yields are significantly greater than the check. With most treatments there were slightly less weeds and slightly more seed from the low rates. Increases in grass population in two treatments are due to grass filling in open spaces resulting from treatment effects on weeds and trefoil in 1963. Table I shows that a rather broad spectrum of weed species were present in all plots one year after treatment; that no particular treatment was inferior, but that most were superior to no treatment at all.

The results from the midsummer treatments in 1963 again show not much difference in broadleaf control in general, although all were much better than no treatment (Figure 2). The elimination of broadleaf competition from the butyric treatments allowed increases in grass growth greater than that in the check, here held in check by excessive broadleaf competition. The grass was greatly suppressed in the simazine treatments. In general, seed yields were much greater from the low rates of the butyrics. Seed yields from the high rate of simazine were outstandingly superior.

Alsike clover, fleabane, and kale were eliminated from a few of the plots receiving high rates of the butyrics (Table II). None of the treatments were completely effective in eradication of most species, although some good suppression was noted.

In the new tests established in April of this year, all treatments were effective in reducing broadleaf weed competition (Figure 3). Unfortunately, most of the space resulting from broadleaf weed losses was soon filled in with quackgrass. Quite outstanding grass reduction was noted, however, for the high rates of simazine and for dichlobenil. Seed yields were superior to the check plots only for the experimental triazine, diphenamid and dichlobenil. The less soluble compounds were apparently not immediately effective.

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Table 1 - Relative Proportions of Various Weed Species in Plots as Percent of Total Broadleafs in Comparison with Checks - May 1963

		Alsike	Chicory	Fleabane	Cinquefoil	Kale	Vetch
Check plot		5	28	30	22	7	8
4(2,4-DB) plots:							
dimethyl-	@ 1½ lb	2	0	3	10	0	10
amine (C)	@ 3/4 lb	6	1	7	2	0	3
isooctyl-	@ 1½ lb	13	3	3	11	0	15
ester	@ 3/4 lb	1	14	5	1	9	3
dimethyl-	@ 1½ lb	14	2	0	0	1	18
amine (A)	@ 3/4 lb	4	1	2	1	0	6
butoxyethanol							
ester	@ 1½ lb	1	2	5	3	7	13
"	@ 3/4 lb	6	0	0	0	0	8

Table 2 - Relative Proportions of Various Weed Species in Plots as Percent of Total Broadleafs in Comparison with Checks - August 1963

		Alsike	Chicory	Fleabane	Cinquefoil	Kale	Vetch
Check plot		17	18	10	23	9	15
Simazine	@ 1½ lb	0	12	0	4	0	32
	@ 3/4 lb	1	16	1	35	0	15
4(2,4-DB) plots:							
dimethyl-	@ 1½ lb	3	1	0	8	0	6
amine (c)	@ 3/4 lb	3	2	1	2	0	27
isooctyl-	@ 1½ lb	4	1	0	8	0	10
ester	@ 3/4 lb	3	8	1	4	2	21
dimethyl-	@ 1½ lb	11	2	0	1	0	7
amine (A)	@ 3/4 lb	6	5	5	2	1	17
butoxyethanol							
ester	@ 1½ lb	3	1	1	1	0	7
"	@ 3/4 lb	1	4	1	1	0	7

Figure 1. Proportions of Broadleaf Weeds and Grass in Plots of May 1963

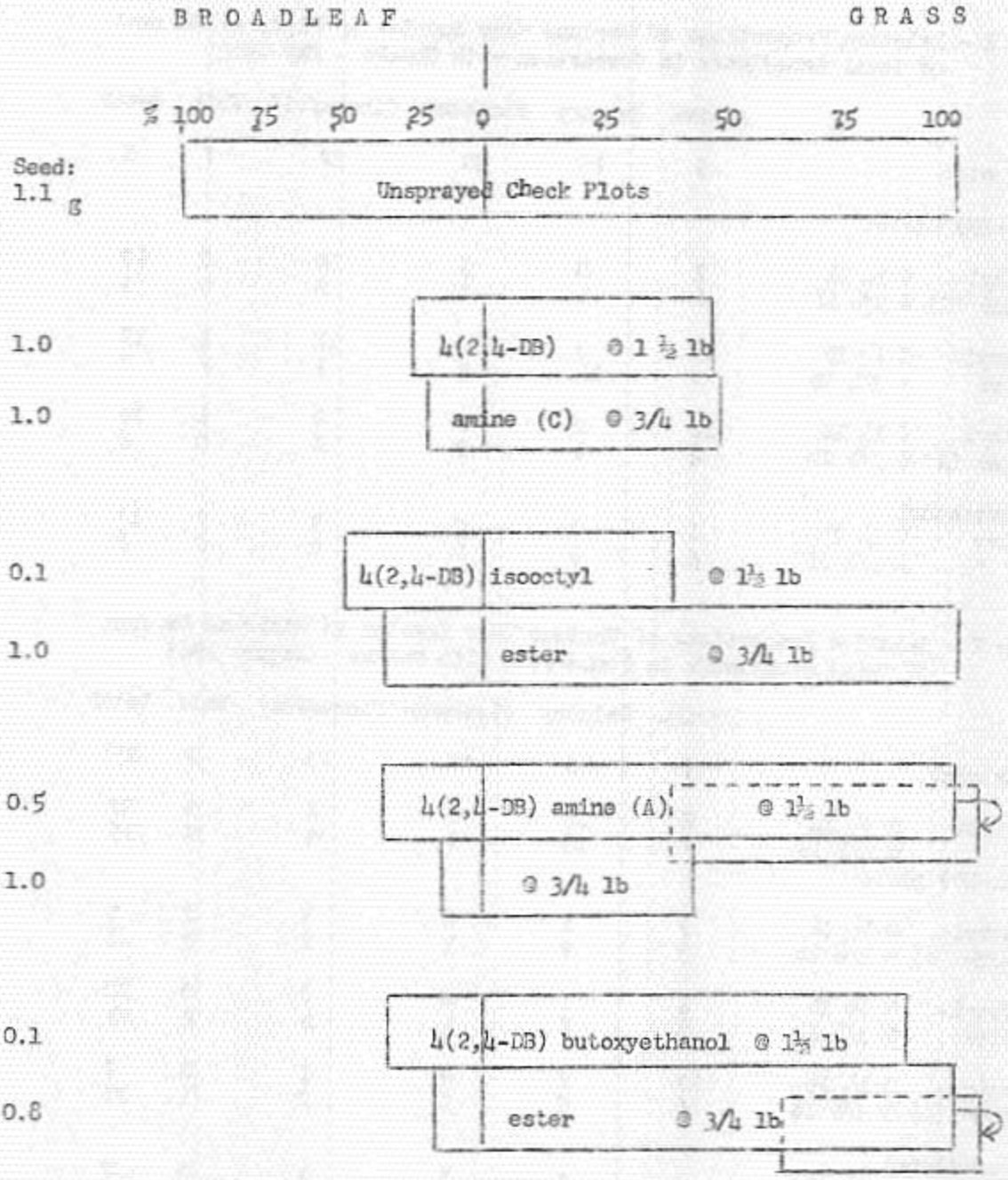


Figure 2. Proportions of Braodleaf Weeds and Grass in Plots of August, 1963

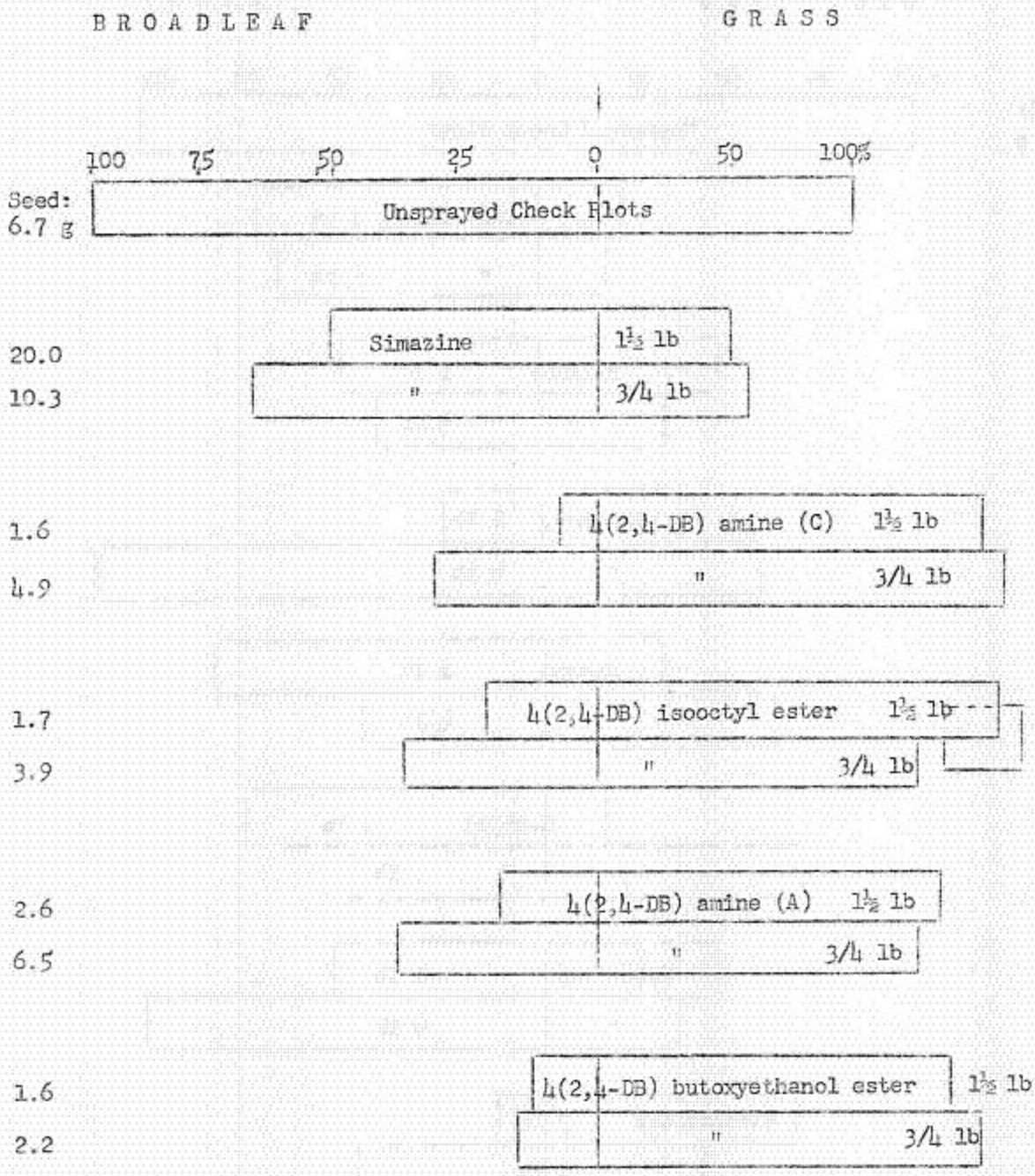
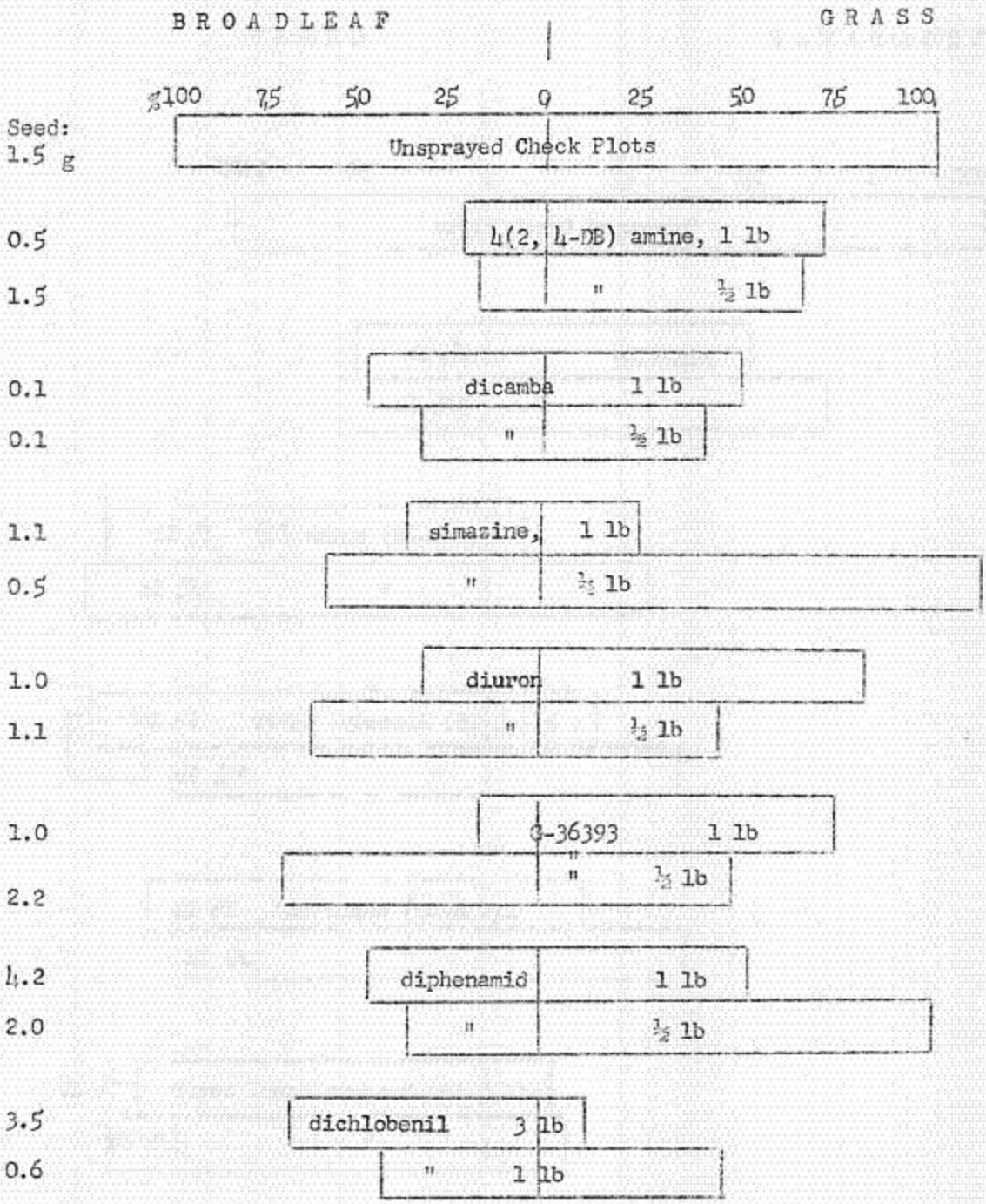


Figure 3. Proportions of Broadleaf Weeds and Grass in Plots of April, 1964



LEGUME SEEDING ESTABLISHMENT WITH HERBICIDES (PROGRESS REPORT)[1/]

D. L. Linscott and R. D. Hagin[2/]

INTRODUCTION

Competition of weeds during the seedling stage of legume establishment continues to be a serious problem for agriculturists in Northeastern United States. Herbicides offer a potential solution to the weed problem in many cases, but continued emphasis needs to be placed on development of new selective chemicals and methods of application. The following progress report deals with data obtained in 1964 from various phases of a legume seeding establishment program.

METHODS AND MATERIALS

Preplanting, Herbicide Incorporated

(1) Standard Methods of Incorporation

EPTC (Ethyl di-n-propylthiolcarbamate) was applied on May 10, 1964 to a Honeoye silt loam at rates of 0, 2, 4 lb/A in 30 gpa of water and incorporated immediately in variables of 0, 1, 2 or 3 tandem diskings or springtooth harrowings. The experimental design involved randomized blocks with split-split plots and 6 replications. Details regarding methodology, seeding rate, fertilizer, etc., are identical to those described for 1963 research (1).

In a second study, H-1318 /1-(2-methylcyclohexyl)-3-phenylurea/, EPTC and trifluralin (2,6-dinitro-N-N-di-n propyl-a,a,a-trifluoro-p-toluidine) were applied to a Honeoye silt loam at rates of 2 and 4, 2 and 4, and 1/2 and 1 lb/A, respectively, and incorporated by a double tandem disking. Three days after treatment (May 21) separate blocks were seeded with Narragansett alfalfa and Empire birdsfoot trefoil at 8 lb/A. The experimental design was a randomized block with 4 replications.

(2) Band Subsurface Placement of Herbicides

EPTC was applied in subsurface bands at 0, 1, 1.5, 2 and 3 lb/A overall (0, 3.5, 5.25, 7.0 and 10.5 lb/A in the band) at the time of seeding using methods and apparatus described previously (1). Two sites were used in this study; the first was located on a Erie-Langford clay loam at Etna, N. Y. and the second on a Honeoye silt loam located at Aurora, N. Y. Liquid EPTC was used at the Etna location. Both liquid and granular formulations were applied at Aurora. Granules (5%) were passed through the boot opening of a grain drill normally used for seeding small grain. Herbicide was placed in a band 2 inches below the legume seed.

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As a postemergence variable of the subsurface banding experiment the amine salt of 2,4-DB [4-(2,4-dichlorophenoxy)butyric acid] was applied at 1 lb/A across all plots. A mowing weed control treatment was applied across all plots as an additional variable in the Aurora experiment. Separate blocks were seeded to Narragansett and Dupuits alfalfa, Empire and Viking birdsfoot trefoil at rates of 8 lb/A at Etna on May 8 and at Aurora on May 18, 1964. Experimental design was a randomized block, split-split plot with six replications. Individual plots were 8 x 24 feet. Postemergence 2,4-DB treatments were applied at Etna June 20 and at Aurora on June 23. Designated plots were mowed on July 2.

Pre- and Postemergence Herbicides

Plots located at Aurora, N. Y. on a Honeoye-Lima silt loam were seeded to Narragansett alfalfa-Climax timothy and Empire birdsfoot trefoil-Climax timothy mixtures at 8 lb/A legume + 6 lb/A grass. Plots were sprayed for preemergence weed control on May 27 with the following chemicals: H-1318, 2 and 4 lb/A; OCS-21964, 2 and 4 lb/A; OCS-21653, 2 and 4 lb/A; trifluralin, 1 and 1 1/2 lb/A; TH-0524, (4,5,7-trichlorobenzthiodiazole-2,1,3) 4 and 8 lb/A; G-36393 (2-isopropylamino-4-methoxyethylamino-6-mercapto-s-triazine), 1 and 1 1/2 lb/A. In addition, paraquat [1:1'-dimethyl-4,4'-dipyridylium di (methylsulfate)] at 1/3 and 2/3 lb/A and OCS-21944 at 2 and 4 lb/A were applied postemergence on June 22 in this series of plots. All herbicides were applied in 30 gpa/water. The design of this and the following experiment was a randomized block-split plot with 4 replications.

Postemergence Herbicides

Plots located at Aurora, N. Y. on a Honeoye silt loam were seeded to Dupuits alfalfa-Climax timothy and Empire birdsfoot-Climax timothy mixtures with 8 lb/A legume, 6 lb/A grass on May 15. Plots were sprayed for postemergence weed control on June 22 with the following herbicides: DNBP (4,6-dinitro-o-sec-butyl phenol) + dalapon (2,2-dichloropropionic acid), 1 + 2 lb/A; MCPA (2-methyl-4-chlorophenoxyacetic acid) + dalapon, 1/4 + 2 lb/A; silvex [2-(2,4,5-trichlorophenoxy) propionic acid] + dalapon, 1/8 + 2 lb/A; 2,4-D (2,4-dichlorophenoxyacetic acid) + dalapon, 1/4 + 2 lb/A; 2,4-DB + dalapon, 1/2 + 2 lb/A; dalapon, 2 lb/A; DNBP, 1 lb/A; MCPA, 1/4 lb/A; silvex, 1/8 lb/A; 2,4-D, 1/4 lb/A; 2,4-DB, 1/2 lb/A; dicamba (2-methoxy-3,6-dichlorobenzoic acid), 1/8 and 1/4 lb/A; H-1318, 2 lb/A; and H-1318 + 2,4-DB, 2 + 1/2 lb/A.

All seedings were made with a grain drill equipped with band seeding and band fertilizer attachments with press wheels. Fertilizer (0-20-20) was applied at 300 lb/A to all experimental plots at the time of seeding.

RESULTS AND DISCUSSION

Preplanting, Herbicide Incorporated

The general overall effectiveness of three herbicides evaluated for weed control in alfalfa and birdsfoot trefoil was as follows: EPTC>trifluralin> H-1318. EPTC was superior to trifluralin for controlling annual broadleaved weeds. (Table 1). Trifluralin controlled annual grasses equally as well as

Table 1. Yield and stand of legume and weeds the year of seeding affected by preplanting-incorporated herbicide applications - 1964[1/]

Item Measured & herbicide	Rate/A	Alfalfa Total	Alfalfa Legume	Alfalfa Grass	Alfalfa BLW	Birdsfoot Trefoil Total	Birdsfoot Trefoil Legume	Birdsfoot Trefoil Grass	Birdsfoot Trefoil BLW
Yield & Composition (1st Cutting-July 29)		Tons	%	%	%	Tons	%	%	%
Control		1.3	39	24	37	1.2	10	16	74
EPTC	2	1.0	95	1	4	0.5	26	9	65
EPTC	4	0.7	94	1	5	0.2	46	3	51
Trifluralin	1/2	1.0	73	1	26	0.5	21	3	76
Trifluralin	1	0.7	73	1	26	0.5	36	3	61
H-1318	2	1.2	45	10	45	0.7	11	14	75
H-1318	4	1.4	40	9	61	0.9	10	13	78
Plants/ft^2 (July 8)			No.	No.	No.		No.	No.	No.
Control			11	4.0	3.0		7	2.0	2.0
EPTC	2		12	0.4	1.0		5	0.7	0.3
EPTC	4		11	0.1	0.4		6	0.1	0.4
Trifluralin	1/2		12	0.8	1.0		7	0.1	0.7
Trifluralin	1		11	0.3	1.0		5	0.2	0.3
H-1318	1/2		11	2.0	2.0		4	4.0	2.0
H-1318	1		11	2.0	2.0		4	2.0	1.0

1/ Yields are presented as oven-dry weight. BLW = Broadleaf weeds.

Table 2. Stand of Viking birdsfoot trefoil and weeds the year of seeding as affected by rate of EPTC applied preplanting and number of disking or harrowing incorporations - 1964.

Incorporations and EPTC Rate	1st Cutting Yield & Composition[1/] Total	Legume	Weed Grass	BLW	Stand in Plants/ft^2[2/] Legume	Weed Grass	BLW
None	T/A	%	%	%	No.	No.	No.
0 lb/A	0.74	39	13	48	13	3.3	2.8
2 lb/A	0.59	50	3	47	14	1.6	1.8
4 lb/A	0.61	58	2	40	13	1.1	1.4
1-2-3- Mean[3/]							
0 lb/A	0.74	39	13	48	13	3.3	2.8
2 lb/A	0.53	66	1	33	14	0.7	1.3
4 lb/A	0.46	79	0	21	13	0.4	0.8

1,2/ Stand and 1st cutting yields were determined on June 29 and July 24, 1964, respectively. BLW = Broadleaf weeds.

3/ In 1963 a single incorporation was as effective as 2 or 3 incorporations, therefore data is combined for simplicity.

EPTC and damaged alfalfa and birdsfoot less. The legumes recovered from herbicide induced stunting by the time of the first cutting. H-1318 was inferior to both EPTC and trifluralin for grass and broadleaved weed control. Some control of annual foxtails was evident but H-1318 had little or no effect on the prevalent broadleaved weeds such as pigweed, ragweed, lambsquarters and wild mustard.

Results of 1964 EPTC incorporation research revealed little benefit from more than one tandem disking or springtooth harrowing incorporations. (Table 2). Excellent control of annual grasses and satisfactory control of mustards, ragweed and redroot was obtained. Unusually good control was obtained with 2 and 4 lb/A EPTC applied to the surface and not incorporated. The reason for increased effectiveness of surface applied EPTC in 1964 depreciating the value of several incorporations may be the result of several factors. The soil surface was very dry at the time of application. Such a condition would have enhanced absorption of the chemical. Further, the evening after seeding, a rainfall of short duration and high intensity puddled the surface. The sealing effect may have prevented rapid volatilization of EPTC.

The band subsurface method for application of herbicides by seeding establishment was successful again in 1964 (Table 3). EPTC applications at 1, 1.5, 2 and 3 lb/A overall (3.5, 5.25, 7 and 10.5 lb/A in the band) gave excellent control of annual grasses, nutsedge and broadleaved weeds. Legume vigor and stand were slightly decreased at the highest rate.

Little overall difference in effect of granular versus liquid EPTC was noted. Liquid application of EPTC in the band appeared to give slightly better weed control, however, the granular formulation stunted legumes less than the liquid. Postemergence 2,4-DB spraying treatments following band applications of EPTC were highly successful in controlling broadleaved weeds. Legumes were not damaged significantly by the additional herbicide treatment.

Postemergence clipping for weed control following band subsurface applications of EPTC at seeding were successful in birdsfoot trefoil plots. Mowing may be the only weed control measure necessary after EPTC band treatments in the case of birdsfoot trefoil. Alfalfa was damaged slightly by the clipping treatment but not of such extent to make the practice undesirable.

Preemergence

Herbicides used for selective preemergence weed control in legume-grass mixture were not successful, with the possible exception of G-36393. G-36393 controlled both grass and broadleaf weeds but reduced alfalfa and birdsfoot trefoil stand and vigor (Table 4). H-1318 at 2 and 4 lbs. and trifluralin at 1 and 1 1/2 lb/A applied preemergence were much less effective than preplanting-incorporated treatments. OCS-21944, OCS-21933 and TH-0524 were not satisfactory at the rates applied.

Postemergence

Chlorinated phenoxy compounds in combination with dalapon, as in previous years, were effective in 1964 for selective weed control in alfalfa and birdsfoot trefoil. A combination of 2,4-DB + dalapon at 1/2 + 2 lb/A killed

Table 3. Yield and stand of alfalfa and birdsfoot trefoil the seeding year as affected by band subsurface placement of EPTC during the seeding operation and 2,4-DB and mowing postemergence treatments (shown on left margin) - 1964

Item Measured, Herbicide and Mowing Treatment	Alfalfa								Birdsfoot Trefoil							
	Total		Legume		Grass		BLW		Total		Legume		Grass		BLW	
	Au.	Etna	Au.	Etna	Au.	Etna	Au.	Etna	Au.	Etna	Au.	Etna	Au.	Etna	Au.	Etna
Plants/ft² 1/			No.	No.	No.	No.	No.	No.			No.	No.	No.	No.	No.	No.
EPTC 0 lb/A			11	30	1.5	3.1	1.5	4.6			8	19	1.5	4.0	1.5	4.7
" 1.0 "			11	31	0.7	3.7	0.8	4.6			12	19	0.8	3.2	0.7	3.8
" 1.5 "			11	35	0.7	3.2	0.6	3.8			9	18	0.7	3.5	0.5	4.0
" 2.0 "			9	34	0.6	3.0	0.6	4.6			9	20	0.5	3.6	0.6	3.8
" 3.0 "			8	33	0.7	3.0	0.6	4.0			7	18	0.3	3.0	0.5	4.4
Yield & Composition 2/ (1st Cutting)	T/A	T/A	%	%	%	%	%	%	T/A	T/A	%		%		%	
EPTC 0 lb/A	.72	.70	88	63	10	22	2	15	.43		52		44		4	
" 1.0 "	.53	.61	94	69	5	21	1	10	.24		78		21		1	
" 1.5 "	.65	.66	91	73	8	17	1	10	.18		84		10		6	
" 2.0 "	.53	.67	96	68	4	19	0	13	.20		87		12		1	
" 3.0 "	.54	.59	95	74	4	14	1	12	.32		87		13		0	
2,4-DB 1 lb/A																
EPTC 0 lb/A	.58		57		10		33		.35		40		27		33	
" 1.0 "	.53		65		4		31		.31		47		5		48	
" 1.5 "	.41		67		7		26		.32		57		12		31	
" 2.0 "	.57		64		6		30		.34		56		4		40	
" 3.0 "	.50		60		8		32		.26		66		2		28	
Mowing																
EPTC 0 lb/A	1.14	.91	62	49	15	12	23	39	.61		29		31		40	
" 1.0 "	.97	.91	67	52	20	15	13	33	.50		46		7		48	
" 1.5 "	.82	.82	70	53	3	12	27	35	.38		54		3		43	
" 2.0 "	.54	1.06	70	49	3	12	27	39	.37		60		3		37	
" 3.0 "	.66	1.04	70	46	3	16	27	38	.36		66		3		31	
Control																

1/ Stands were determined on Aurora (Au.) plots June 29, 1964 and Etna plots June 25, 1964.

2/ Yields were taken at Aurora July 23, 1964 and Etna July 22, 1964. Yields are expressed in oven-dry weights.

Table 4. Yield and stand of legumes and weeds the year of seeding as affected by preemergence and postemergence treatments.

Item measured, herbicide		Rate lb/A	Alfalfa Total	Alfalfa Legume	Alfalfa Grass	Alfalfa BLW	Birdsfoot Trefoil Total	Birdsfoot Trefoil Legume	Birdsfoot Trefoil Grass	Birdsfoot Trefoil BLW
Plants/ft^2 1/				No.	No.	No.		No.	No.	No.
	Control			7.7	6.5	4.3		5.2	2.1	1.9
Preemergence	H-1318	2		9.7	7.0	3.7		3.0	1.7	1.1
	H-1318	4		5.7	4.3	3.6		2.8	1.7	1.8
	OCS-21944	2		8.4	5.1	3.6		4.5	1.6	1.1
	OCS-21944	4		6.3	3.0	2.4		3.1	2.4	2.0
	OCS-21933	2		8.4	4.5	4.2		4.6	1.7	1.2
	OCS-21933	4		6.3	1.8	1.8		4.2	1.7	2.1
	Trifluralin	1		6.7	4.5	3.5		6.5	1.9	1.8
	Trifluralin	1.5		7.1	1.9	3.0		4.9	1.3	1.8
	TH-0524	4		3.5	2.2	2.0		2.8	0.9	1.1
	TH-0524	8		1.0	0.4	0.9		5.0	1.3	1.4
	G-36393	1		6.7	1.0	1.0		1.0	0.7	1.9
	G-36393	1.5		5.7	1.2	0.8		0.8	0.5	0.4
Post-Emergence	Paraquat	1/3		3.0	0.9	1.1		0.1	0.2	0.8
	Paraquat	2/3		1.1	0.2	1.0		1.7	0.3	0.6
	OCS-21944	2		6.9	9.1	2.7		4.5	1.8	1.2
	OCS-21944	4		6.1	5.4	1.8		3.4	2.6	1.3
Yield & Composition 2/			T/A	%	%	%	T/A	%	%	%
	Control		.66	10	11	70	.62	9	11	80
Preemergence	H-1318	2	.72	12	10	78	.51	5	5	90
	H-1318	4	.60	10	7	83	.64	9	6	85
	OCS-21944	2	.79	13	7	80	.61	10	6	84
	OCS-21944	4	.72	7	6	87	.60	19	1	80
	OCS-21933	2	.65	13	9	78	.57	18	4	78
	OCS-21933	4	.78	5	7	88	.61	11	4	85
	Trifluralin	1	.54	8	5	87	.50	21	8	73
	Trifluralin	1.5	.77	8	2	90	.46	6	4	90
	TH-0524	4	.44	5	5	90	.65	6	5	89
	TH-0524	8	.44	2	0	98	.50	24	4	72
	G-36393	1	.37	35	5	62	.20	3	6	91
	G-36393	1.5	.34	20	4	76	.13	31	18	51
Post-Emergence	Paraquat	1/3	.25	12	1	85	.61	1	3	96
	Paraquat	2/3	.09	5	2	98	.03	1	4	95
	OCS-21944	2	.57	10	17	73	.54	15	16	69
	OCS-21944	4	.41	7	20	73	.45	4	21	75

broadleaved and grass weeds most successfully and had little effect on legumes. MCPA and 2,4-D + dalapon at 1/4 + 2 lb/A were equally as good or better than 2,4-DB + dalapon for controlling weeds but stunted legume growth more. Silvex or DNBP, and dalapon combinations controlled weeds but damaged the legumes severely, especially birdsfoot trefoil.

Of the relatively new compounds applied postemergence, paraquat and dicamba reduced stand of alfalfa and birdsfoot trefoil considerably (Tables 4 and 5). Legumes are not resistant enough to the effects of paraquat for this compound to have promise as a postemergence chemical in seedings. Weed control was quite satisfactory. Birdsfoot trefoil was more tolerant of dicamba than alfalfa and may possibly be used for broadleaved weed control in birdsfoot trefoil. Dicamba is not effective on annual grass. H-1318 applied postemergence at 2 lb/A did not give satisfactory grass or broadleaved weed control.

SUMMARY

(1) EPTC and trifluralin applied preplanting-incorporated at 2 and 4 and 1/2 and 1 lb/A, respectively, gave excellent annual weed grass and broadleaf weed control in both alfalfa and birdsfoot trefoil. H-1318 applied preplanting-incorporated at 2 and 4 lb/A controlled some annual grasses but was not effective on broadleaved weeds. One incorporation of EPTC at 2 and 4 lb/A by tandem disking and springtooth harrowing was nearly as effective as 2 or 3 incorporations. Effective weed control was obtained with surface applications of EPTC in 1964.

Band subsurface placement of EPTC at the time of seeding continued to show promise as a weed control practice.

(2) Of several preemergence chemicals evaluated in 1964 only G-36393 showed promise for selective weed control. This chemical damaged birdsfoot trefoil badly and was harmful to alfalfa at 1 lb/A rate. Of the relatively new herbicides for postemergence application, dicamba showed some promise for broadleaved weed control in birdsfoot trefoil. Dicamba damaged alfalfa severely after 1/2 - 1/4 lb/A treatments.

(3) Several phenoxy derivitives and dalapon, singly or in combination, continued to prove satisfactory for postemergence weed control in alfalfa and birdsfoot trefoil. Outstanding treatments for weed control were 2,4-DB + dalapon, 2,4-D + dalapon, and MCPA + dalapon. DNBP + dalapon was satisfactory for weed control in alfalfa and birdsfoot trefoil seedings but damaged both legumes to some extent. Silvex + dalapon was effective in controlling weeds but damaged legumes extensively.

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Table 5. Yield and stand of legume and weeds the year of seeding as affected by postemergence herbicides

Item measured, herbicide	Rate lb/A	Alfalfa Total	Alfalfa Legume	Alfalfa Grass	Alfalfa BLW	Birdsfoot Trefoil Total	Birdsfoot Trefoil Legume	Birdsfoot Trefoil Grass	Birdsfoot Trefoil BLW
Plants/ft²[1/]			No.	No.	No.		No.	No.	No.
Control			9	7	0		13	6	8
DNBP + Dalapon	1 + 2		6	5	3		3	5	4
MCPA + Dalapon	1/4 + 2		9	4	6		12	2	6
Silvex + Dalapon	1/8 + 2		6	4	5		10	3	7
2,4-D + Dalapon	1/4 + 2		11	4	4		10	3	4
2,4-DB + Dalapon	1/2 + 2		9	5	3		17	3	5
Dalapon	2		10	4	6		11	2	6
DNBP	1		9	7	3		10	6	5
MCPA	1/4		8	10	5		12	7	6
Silvex	1/8		6	11	5		9	10	5
2,4-D	1/4		9	9	2		11	9	2
2,4-DB	1/2		10	8	3		16	11	5
Dicamba	1/8		5	14	2		11	8	3
Dicamba	1/4		4	12	4		9	12	2
H-1318	2		8	7	6		16	9	9
H-1318 + 2,4-DB	2 + 1/2		9	9	3		11	8	3
Yield & Composition[2/] (1st Cutting)		T/A	%	%	%	T/A	%	%	%
Control		.68	21	10	69	.58	5	10	85
DNBP + Dalapon	1 + 2	.32	16	13	71	.34	5	6	89
MCPA + Dalapon	1/8 + 2	.35	24	5	71	.33	9	5	86
Silvex + Dalapon	1/8 + 2	.19	13	13	75	.19	14	6	80
2,4-D + Dalapon	1/4 + 2	.14	50	36	14	.12	41	21	41
2,4-DB + Dalapon	1/2 + 2	.54	34	26	40	.34	16	5	79
Dalapon	2	.47	15	0	85	.60	6	1	93
DNBP	1	.49	15	21	64	.49	9	35	56
MCPA	1/4	.48	19	58	24	.43	8	45	48
Silvex	1/8	.46	8	73	20	.63	10	66	24
2,4-D	1/4	.32	35	63	3	.39	14	79	8
2,4-DB	1/2	.45	35	44	21	.39	13	54	34
Dicamba	1/8	.35	11	89	0	.36	10	88	3
Dicamba	1/4	.53	13	86	1	.46	13	88	0
H-1318	2	.70	9	5	86	.61	5	14	83
H-1318 + 2,4-DB	2 + 1/2	.52	41	58	1	.42	9	53	39

1/ Stands were determined July 8, 1964.

2/ Yields were taken July 31, 1964. Yields given in oven-dry weight.

CONTROL OF WINTER ANNUAL WEEDS IN ALFALFA SEEDINGS[1]

R. C. Wakefield and J. O. Pearson[2]

Introduction

Development of selective herbicides has made possible control of summer annual broadleaf weeds in spring seedings of alfalfa and other legumes. This has generally resulted in better establishment of plants and a substantial yield of weed-free forage during the seeding year (2)(3). Delaying seeding to the late summer period usually avoids serious infestation of summer annual weeds but frequently results in competition from winter annuals such as chickweed (Stellaria media), wild radish (Raphanus raphanistrum), yellow rocket (Barbarea vulgaris), shepherd's purse (Capsella bursa-pastoris) and others. Control of chickweed has received much more emphasis than other winter annual weeds (1)(4).

The present study was initiated to evaluate several pre- and post-emergence herbicides on winter annual weed species, principally shepherd's purse and chickweed.

Procedure

A weed control experiment was initiated on the Agronomy Plots of the R. I. Agricultural Experiment Station on August 26, 1963. The area selected for the study had a history of heavy and fairly uniform infestations of several winter annual weed species. Treatments were replicated in four randomized blocks with an individual plot size of 6x20 feet.

Fertilizer was incorporated prior to seeding to provide 150 pounds per acre of both P_2O_5 and K_2O. Narragansett alfalfa was seeded at 15 pounds per acre with a cultipacker-type seeder on August 26.

Herbicides were applied in 30 gallons of water per acre with a bicycle-type sprayer equipped with a 6-foot boom. Chemicals are listed in the Appendix. The times of application and stages of plant development were as follows:

a. Incorporated (EPTC, trifluralin) - August 26.
b. Preemergence (diphenamid, diphenamid plus trifluralin) - August 26.
c. Postemergence (4(2,4-DB), DNBP, ACP 63-57) - September 26, alfalfa 2-3 true leaf stage.

Plots were harvested on June 23, 1964 and August 11, 1964. A 3x16 foot strip was removed from each plot and weighed. Sub-samples were taken for dry

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matter determinations on all plots. Botanical composition was estimated prior to the first cutting.

Results and Discussion

Weather Conditions

Soil moisture was rather low at the time of seeding on August 26, 1963 and rainfall was sparse for the following two-week period. In addition temperatures were cool, with September being 3.6 degrees below normal. As a result germination of alfalfa was delayed and growth of seedling plants was very slow through the fall growing period.

Winter conditions alternated from periods of adequate snow cover to open and often ice sheet cover on experimental plots. Injury to alfalfa plants was evident during the last week of January and the first two weeks of February as alternate periods of freezing and thawing of open ground occurred. Heaving of alfalfa plants was most severe where weed control was successful and bare soil was exposed to a greater extent.

Weed Populations

A uniformly heavy infestation of shepherd's purse (*Capsella bursa-pastoris*) developed as expected from prior observations. Approximately 3-5 plants were present per square foot. A uniform stand of chickweed (*Stellaria media*) also developed during September. It was felt that the shepherd's purse would serve as a test species for the mustard group of winter annuals.

Yield data are presented in Table 1.

Evaluation of Incorporated and Pre-emergence Herbicides

Trifluralin was incorporated prior to seeding at 3/4 and 1 pound (ai) per acre. The material failed to control shepherd's purse at either rate but was effective on chickweed, particularly at the higher rate.

Diphenamid at 2 and 4 pounds (ai) per acre was, similarly, not effective on shepherd's purse but excellent on chickweed. Alfalfa was noticeably injured by the high rates of both trifluralin and diphenamid. A combination of trifluralin and diphenamid at the low rate of each gave excellent control of chickweed with no injury to the alfalfa.

Control of chickweed by trifluralin was accompanied by a significant increase in the yield of shepherd's purse. This was undoubtedly due to removal of the competitive influence of chickweed on the species balance.

EPTC at a rate of 4 pounds per acre did not control either weed species to any significant degree.

Table 1. Yields of alfalfa and weeds following herbicide treatments. Kingston, R.I. 1964.

Herbicide treatments	Rate lb/A ai	Yield - Tons dry matter per acre: Cutting - 6/13/64: Alfalfa	Shepherd's purse	Chickweed	Cut 8/11/64 alfalfa	Total alfalfa
Incorporated						
Trifluralin	3/4	.79 abc*	.65 ab	.12 bcde	.80 ab	1.59 abcd
Trifluralin	1½	.69 bc	.93 a	.00 f	.77 ab	1.46 bcd
EPTC	4	.88 abc	.52 bcd	.09 def	.82 ab	1.70 abcd
Preemergence						
Diphenamid	2	.94 abc	.29 cdef	.04 ef	.88 ab	1.82 abcd
Diphenamid	4	.66 bc	.26 def	.00 f	.63 b	1.29 cd
Diphenamid plus Trifluralin	2+3/4	.91 abc	.43 bcde	.00 f	.72 ab	1.64 abcd
Postemergence						
4(2,4-DB) amine	3/4	1.20 a	.01 f	.23 ab	.94 a	2.14 a
4(2,4-DB) amine	1½	1.13 a	.00 f	.20 abcd	.76 ab	1.90 ab
4(2,4-DB) ester	3/4	.97 abc	.00 f	.22 abc	.77 ab	1.74 abcd
4(2,4-DB) ester	1½	.88 abc	.00 f	.14 abcde	.84 ab	1.73 abcd
ACP 63-57	3/4	1.04 ab	.16 ef	.24 a	.80 ab	1.84 abcd
ACP 63-57	1½	1.02 ab	.09 ef	.16 abcd	.76 ab	1.78 abcd
DNBP	1	1.03 ab	.19 def	.10 cdef	.74 ab	1.78 abcd
No Treatment						
Control	-	.81 abc	.34 cdef	.19 abcd	.87 ab	1.69 abcd

*Values for a given column followed by a similar letter are not significantly different at the 5% level.

Evaluation of Post-emergence Herbicides

The 2,4-D butyrics were used at 3/4 and 1-1/2 pounds per acre as the dimethylamine and iso-octyl ester formulations. Shepherd's purse was effectively controlled at the two rates and by both formulations. Chickweed however was not affected. Alfalfa did not appear to be injured by the amine formulation although there was slight injury from the ester at the 1-1/2 pound rate. Yields were generally not significantly different from the check plots.

The experimental herbicide, ACP 63-57, was not particularly effective in controlling either shepherd's purse or chickweed.

Dinitro was used at 1 pound per acre. Initial control of chickweed was good but subsequent germination and growth of the species occurred.

Winter Injury to Alfalfa

Heaving of alfalfa plants during the winter was substantial and was actually more serious where weeds, particularly chickweed, were controlled. The "mulching effect" of weed growth appeared to reduce alternate freezing and thawing of the soil to some extent thus reducing injury to alfalfa plants. This factor may have reduced the potential of 4(2,4-DB), trifluralin and diphenamid to increase yields of alfalfa in this experiment.

Summary

Herbicides were evaluated for control of winter annual weeds in a late summer seeding of alfalfa. Weed species encountered were chiefly shepherd's purse (*Capsella bursa-pastoris*) and common chickweed (*Stellaria media*).

Excellent control of shepherd's purse was achieved with a September application of 4(2,4-DB) on seedling alfalfa. Rates of 3/4 and 1-1/2 pounds per acre were equally effective as were the amine and ester formulations. 4(2,4-DB) failed to control chickweed.

Both trifluralin and diphenamid applied alone or in combination at 3/4 and 2 pounds per acre respectively effectively controlled common chickweed. Higher rates caused injury to alfalfa and reduced yields.

DNBP, EPTC and ACP 63-57 were generally not effective in controlling winter annual weed species encountered in this experiment.

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Appendix

Herbicides used in this study were as follows: (Companies supplying materials are noted.)

1. Ethyl-n,n-di-n-propylthiolcarbamate (EPTC), 6 lb AE/gal. Stauffer Chemical Company.

2. 2,6-dinitro-N,N-di-n-propyl-a,a,a-trifluoro-p-toluidine (trifluralin), 4 lb AE/gal. Eli Lilly and Company.

3. N,N,dimethyl 1,2,2-diphenylacetamide (diphenamid), 80% WP. Eli Lilly and Company.

4. 4(2,4-dichlorophenoxy) butyric acid, dimethylamine salt and iso-octyl ester 4(2,4-DB), each 2 lb AE/gal. Chipman Chemical Company, Amchem Products.

5. Dinitro-O-sec-Butyl-phenol, alkanolamine salt (DNBP), 3 lb AE/gal. Dow Chemical Company.

6. N-(3,4-dichlorophenyl)-2,2-dimethyl valeramide (ACP 63-57), 1.5 lb AE/gal. Amchem Products.

EFFECTIVENESS OF HERBICIDES FOR CRABGRASS CONTROL IN CORN

Robert A. Peters[1]

Because of the generally favorable annual weed control obtained, atrazine has been the most commonly used herbicide for corn weed control for several years in the Northeast. In Connecticut, at least, cultivation following atrazine application is now seldom employed.

Each year there is an increasing number of reports of crabgrass in corn fields treated with atrazine. Crabgrass has been shown to be relatively resistant to atrazine.[2] Normally only one of many species found in the summer annual weed complex in corn fields, crabgrass is released from competition from other weeds controlled by atrazine. An ecological shift has occurred with crabgrass becoming more prevalent each year. The trend towards mono-culture associated with yearly application of atrazine on corn grown continuously on the same field has aggravated this shift.

The seriousness of the heavy crabgrass stands now being encountered in southern New England in terms of reduction in corn yields is not yet known. There is little question, however, of the disadvantage of the heavy build-up of crabgrass seed in the soil since crabgrass can be a serious competitor to some crops which frequently are grown in rotation with corn.

Procedure

The experiment detailed below was carried out on the Agronomy Research Farm of the Storrs (Conn.) Agricultural Experiment Station. The experimental area was on a Paxton fine sandy loam soil fertilized with 125 lb/A of N, P_2O_5 and K_2O respectively. Pa corn 602A was planted on June at a rate of 20,000 stalks per acre. Corn treated with

1. Agronomist, Plant Science Department, University of Connecticut, Storrs, Conn.

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. 1962

atrazine had been grown in the same field for two years previously. Large crabgrass (Digitaria sanguinalis) was the dominant species. The stand in the check on July 8 was over 15 plants per square foot. Ragweed (Ambrosia artemisiifolia) and Lambsquarter (Chenopodium album) were present in smaller numbers.

The size of the plots were 30 by 9 feet replicated three times. Each plot had three rows of corn spaced 36 inches apart. The center row was harvested for yield determinations. Periodic density ratings of the crabgrass growth were made using 0-10 scale with 0 referring to no stand and 10 referring to maximum density of stand. Actual stand counts were on July 8 by counting the number of plants in a two square foot quadrat placed at random in each plot. Yields of corn were based on oven-dry weights determined on September 24 when the corn was in the early dent stage.

While rainfall was below normal for the season the corn did not appear to suffer for lack of water.

Chemical Treatments

All but the directed post-emergence application of linuron was applied with a bicycle-type compressed air sprayer at 40 gallons of solution per acre. Pre-emergence applications were made on June 8, 1964 just as the corn was starting to emerge. The soil was quite dry but rain fell on the 2, 3 and 4th day after application.

The post-emergence application of atrazine was made on June 23 when the corn was in the 5 leaf stage and 8 in. tall. Large crabgrass was ½-2 in. tall and startint to tiller.

The directed post-emergence application of linuron was made on July 11 with a knap sack sprayer. The corn was 24 in. tall and the crabgrass was 3-6 in. tall with a spread up to 8 in.

Results and Discussion

Crabgrass Control

The control of crabgrass was measured in two ways; by an actual stand count and by ratings on two dates of the total density of growth.

Table I
Control of Large Crabgrass from Herbicide Treatments
and Associated Silage Corn Yields.

Chemical Treat. lb/A a.e. or a.i.		Stand counts per sq. ft.-7/8 total	L/S [1]	Crabgrass density ratings 0-10 7/1/64	7/19/64	Corn Silage T/A 25% D.M.	[2]
Check		16.7	5.7	8.7	9.7	7.0	a
2,4-D LV ester	1	12.5	1.3	3.3	6.7	15.6	abc
Atrazine	1½	16.4	6.4	6.0	8.0	15.7	abc
Atrazine (post)	2	12.9	7.1	7.0	8.7	16.0	abc
Linuron	1	9.9	4.2	3.0	6.0	16.2	bcd
Atrazine	2	11.3	2.2	4.0	8.7	16.6	bcd
Simazine	2	8.1	1.1	3.7	7.7	16.8	bcd
R-1910+2,4-D	2+ ½	5.5	.9	3.3	6.0	17.7	bcd
Atrazine + Prometryne	1+ 1	9.8	1.4	3.0	6.0	17.8	bcd
Linuron (Post-directed)	2	17.0	5.8	7.0	3.0	18.0	bcd
Atrazine + Simazine	1+ 1	7.9	1.8	3.3	8.5	18.0	bcd
Carbide 22463	6	9.1	.2	3.3	7.7	18.2	bcd
Amiben	2	5.1	.2	1.7	6.7	18.6	bcd
2,4-D LV ester	2	14.4	.2	1.3	4.7	18.8	bcd
Falone+DNBP	2+1½	8.3	.8	2.7	2.3	19.0	bcd
Carbide 22463	3	10.4	1.1	3.0	9.3	19.1	bcd
Ametryne	2	5.5	.8	2.7	4.0	19.1	bcd
EPTC+2,4-D	4+ 2	5.0	.06	3.0	0.7	19.3	bcd
Linuron	2	7.4	.3	3.3	7.7	19.8	cd
EPTC+2,4-D	2+ 1	6.2	.2	.1	1.6	20.0	cd
Atrazine + Ametryne	1+ 1	11.0	2.3	3.7	2.2	20.7	cd
R-1910 + 2,4-D	4+ 1	3.7	.4	1.7	2.3	21.3	cd
Prometryne	2	10.2	1.0	3.0	6.0	21.4	cd
Atrazine + Amiben	1+ 2	4.1	.2	1.4	1.7	22.0	cd

1/ Ratio of large (over 2 in. in diameter) to small crabgrass plants (less than 2 in.)

2/ Yields followed by a common letter are not significantly different at the .05 level.

The density ratings of July 1, 1964 indicated a 50% or greater reduction from all pre-emergence treatments except atrazine at 1 lb/A. The atrazine and linuron 2 lb/A post-emergence applications had a high rating since it had not been sprayed by that date.

As rated on July 19, 41 days after treatment, only a few of chemicals had effectively held back crabgrass growth. The chemical treatments which gave relatively long term control were atrazine 1+ amiben 2 lb/A, EPTC + 2,4-D at both rates, R-1910 + 2,4-D at the higher rate, atrazine 1+ ametryne 1 lb/A, falone 2 + DNBP 1½ lb/A and ametryne 2 lb/A. The post-directed spray applied on July 11, 1964 gave effective crabgrass control. By the end of the season the plots with this treatment were entirely free of weed growth.

Actual stand counts on July 8 showed that none of the pre-emergence treatments gave complete kill of crabgrass. Treatments resulting in stands 60% or less than in the check were R-1910 or EPTC combined with 2,4-D, amiben 2 lb/A, ametryne 2 lb/A and atrazine 1 + amiben 2 lb/A. There was in general a good correlation between stand counts of July 8 and the density ratings of July 19. There were, however, some distinct exceptions. Amiben had a low stand count of 5.1 plants per square foot but a high density rating of 6.7. The rates of large to small plants (L/S) of .2 showed a preponderance of small plants. This indicated a short residual effect from the amiben resulting in reestablishment of crabgrass. The same trends were seen with linuron 2 lb/A and with atrazine + Simazine 2 lb/A.

The combination of atrazine 1 + amiben 2 lb/A was effective in holding down crabgrass as judged by the low density on July 19 and the high corn yield. The number and ratio of large to small plants was, however, the same as for amiben alone. These results indicate that germination of crabgrass was delayed when atrazine was added to the mixture which resulted in a lower total density.

Conversely, two treatments had relatively high stand counts but low density ratings on July 19, 1964. These treatments were atrazine 1 + ametryne 1 lb/A and falone 2 + DNBP 1½ lb/A. Since 15 and 9 large plants per square foot remained after treatment with atrazine + ametryne and falone + DNBP, respectively, the low density ratings in July 19, 1964 were due to stunting of crabgrass plants.

The increased density ratings on July 19 for several treatments given a low rating on July 1 were due in most cases to proliferation of the crabgrass plants not controlled by the pre-emergence applications. By late July these plants had sprawled and tillered so profusely that ratings by visual inspection were as high as in plots having a much higher actual total stand count. Studies at the Storrs Station on crabgrass biology have shown the capability of a single large crabgrass plant in spaced nurseries to spread over 3 feet in diameter by the end of the growing season.

This prolific tillering of crabgrass results in crabgrass stands which, in a few weeks, appear as dense as plots with slight control in terms of stand counts.

Yield of Silage Corn

All treatments but three resulted in a significant increase in corn silage over the check as based on the Duncan's multiple range test at the .05 level of significance. The three treatments were atrazine 1 lb/A or 2,4-D LV ester 1 lb/A applied pre-emergence and atrazine 2 lb/A applied post-emergence.

Yields from the other treatments ranged from a high of 23 T/A to a low of 16 T/A of silage corn. None of the differences were significant.

Some corn injury was observed in three treatments. The high rate of EPTC + 2,4-D caused onion rolling of few plants. Carbide 22463 caused chlorotic streaks in the first leaf but the condition did not persist. Considerable contact injury of the lower leaves resulted from the direct application of 2 lb. of Linuron.

There was only a limited correlation between crabgrass counts on July 3 and corn yields. Two of the top yields were correlated with the lowest crabgrass counts, namely, R-1910 4+ 2,4-D 1 lb/A and atrazine 1 + amiben 2 lb/A. High yields were also obtained from prometryne and atrazine + ametryne with a stand count 2/3 of the check for either treatment.

A better correlation was found between corn yield and plant density. All treatments with a density rating of 2.5 or below on July 19, 1964 had a silage yield of 19 tons or greater. The stand count in this same group ranged from 37 to 11 plants per square foot.

Judging the degree of competition from crabgrass in corn is complicated by the spread of only a few plants resulting in the ground becoming entirely covered. The prolific tillering characteristic of this species makes some measure of total crabgrass growth of much more ecological significance than a count of total number of plants.

The degree of crabgrass infestation in this experiment would be ranked high compared to most corn fields. Crabgrass control was in general quite incomplete but corn yields were not seriously depressed despite the rank growth of crabgrass. Control of the relatively light infestation of broadleaf weeds present had apparently as much effect on corn yields as did control of the heavy stand of crabgrass.

RESULTS OF 1964 RESEARCH ON WEED CONTROL IN CORN

Stanford N. Fertig and Armin H. Furrer, Jr. 1/

INTRODUCTION

Farmers doing the best job of corn production in New York are those giving full consideration to a complete package of production practices from the best adapted hybrid for planting to storage of the harvested crop. Failure to follow through on all practices can nullify the benefit of doing most of them correctly. A significant weakness in the program of thousands of growers is inadequate weed control. The past two seasons has dramatized this weakness but none so significantly as the very dry season of 1964.

In many sections of New York, 1964 was a poor corn year regardless of the program followed, but the difference between some degree of success and complete failure was the timing and effectiveness of the weed control program.

METHOD AND PROCEDURE

The 1964 research trials included incorporated, preemergence, and postemergence applications. Chemicals varied from the accepted standards to the most recent experimental compounds. Comparisons were made with and without soil incorporation, wetting agents and cultivation.

The plot area chosen for the 1964 trials was known to be infested with nutsedge, hedge bindweed, milkweed, horse nettle, and ground cherry. These and other perennial species represent the future weed problem of corn in New York.

The experimental area was spring plowed, fitted, and planted to variety Funk G-11-A on May 27, 1964. All planting was done using a 6-row John Deere planter adjusted to give a plant population of 22,500 and a fertilizer rate of 350 pounds of 10-20-10. The plot size was 15 x 30 feet, with a row spacing of 30 inches.

The incorporated herbicides were applied prior to planting and incorporated within 15 minutes after application by double discing. The pre- and postemergence treatments were applied using a modified Allis Chalmers-G tractor or a knapsack-CO_2 sprayer.

All plots received a broadcast application of 10 pounds of mustard, 15 pounds of yellow foxtail and a mixture of 1 pound of lambsquarters and rough pigweed per acre.

1/ Professor and Research Specialist, respectively, Agronomy Department, Cornell University.

Plots receiving a single cultivation were tilled 3 weeks after planting regardless of the herbicide treatment. Where 2 cultivations were performed, the second was 14 days after the first.

Yields were determined by harvesting the 3 center rows from each plot using a Gleaner-Baldwin 3 row picker-sheller. The total plot yield was weighed, and a 1,000 gram sample taken for moisture determination. The yields in bushels per acre at 15 percent moisture were calculated from these values. The yields reported are based on 3 replications of each treatment.

RESULTS AND DISCUSSION

Preplant Incorporated

The most promising treatments for the control of nutsedge were R-1910 or Eptam incorporated, R-1910 incorporated in combination with 2,4-D, or R-1910 or Eptam incorporated followed by pre- or early postemergence applications of 2,4-D or atrazine (Table 1).

When applied alone at rates of 3 to 4 pounds, R-1910 was more effective in controlling nutsedge but less effective than Eptam on annual broadleaved species. The R-1910 also showed less injury on the corn.

Comparing R-1910 or Eptam in combination with 2,4-D, the R-1910 plus 2,4-D was weaker on broadleaves but more effective on nutsedge. Also, the use of 2,4-D preemergence was superior for annual grass control compared to mixing it with the R-1910 or Eptam and incorporating both preplant. The value of the 2,4-D would appear to be improved annual broadleaved control. There was no improvement in nutsedge or annual grass control over R-1910 or Eptam alone.

The combination of R-1910 or Eptam with Atrazine, where the Atrazine was applied pre- or early postemergence, resulted in better control of all species. The advantage of Atrazine over 2,4-D was better control of annual broadleaves and annual grasses. The R-1910 plus Atrazine was equal in effectiveness to Eptam plus Atrazine. In view of this, R-1910 would be favored because of less corn injury.

Where rate per acre of R-1910 or Eptam was compared, three pounds per acre was just as effective as four pounds on nutsedge and annual grasses but was less effective on annual broadleaves. Since, cultivation is an integral part of effective nutsedge control, the three pound rate would be very satisfactory.

Based on effectiveness of control in mixtures with R-1910 or Eptam, Atrazine applications preemergence were more effective than postemergence. Preemergence applications would also favor more adequate rainfall for Atrazine activation.

Preemergence Applications

The most promising compound in the 1964 trials for preemergence control of nutsedge was CP-31393 at rates of 4 and 6 pounds per acre. The 6 pound rate reduced the stand of nutsedge by 80-85 percent. It also looked good on annual grasses but was weak on annual broadleaves (Table 2).

Compounds which caused stunting and necrosis of nutsedge and in combination with cultivation might give commercial control included Atrazine and H-150. However, Atrazine as an early postemergence treatment plus cultivation has been more effective on nutsedge.

Linuron at rates of 1 to 2 pounds was comparable in effectiveness to Atrazine for annual broadleaved and annual grass control. There was no evidence of corn injury when used preemergence on medium to heavy textured soils but the yields of corn were lower than those of Atrazine. A significant limitation of Linuron is its ineffectiveness on nutsedge(Tables 2 and 3).

Preemergence applications of the following compounds were effective for broadleaved and annual grass control but were ineffective on nutsedge and perennial broadleaved weeds: Amiben plus Atrazine, Amiben plus Linuron, Atrazine plus CP-31393, C-2059, H-137, H-149, H-150 and Niagara 7251.

Compounds effective for annual grass control but ineffective on annual broadleaves, nutsedge and perennial broadleaves were: Amiben plus CP-31393, and Amiben alone.

Compounds effective on annual broadleaves but ineffective on annual grasses, nutsedge and perennial broadleaves were: Eptam plus 2,4-D, R-1910 plus 2,4-D and H-95-1.

Compounds included in the 1964 trials as preemergence treatments which did not show promise on annual broadleaves, annual grasses, nutsedge or perennial broadleaves were: SD-9813, SD-9796, SD-9515 and TM-052-H.

Postemergence Applications

Nutsedge was not effectively controlled by any postemergence treatments included in the 1964 trials. The most promising was Atrazine plus 1 cultivation plus Atrazine. It is doubtful that such a combination treatment would be favorably received by growers.

The most promising postemergence development was the use of low rates of Atrazine or Simazine with a non-phytotoxic oil (Table 4). Based on the control of annual broadleaves and annual grasses, 1/2 pound of Atrazine or Simazine was about as effective as 1-1/2 pounds without oil.

Another compound worth further evaluation is the combination of grass control compounds with Banvel-D (Table 5). With the increase in perennial broadleaved species, this may prove highly beneficial.

Compounds showing promise as early postemergence treatments for the control of annual broadleaved weeds were: Banvel-D, Banvel-D + 2,4-D, Banvel-D + Atrazine, C-2059, C-3126, and Ioxynil + Amiben. However, as postemergence treatments, Banvel-D, Banvel-D + Atrazine, Banvel-D + 2,4-D, Amiben + Ioxynil, Atrazine + Ioxynil, and C-2059 were weak on annual grasses (Table 5).

Table 1

Chemical Method of Treatment, Weed Control Rating, Plant Population, and Yield of Field Corn, Aurora Farm, 1964.

Trent. No.	Chemical	Rate/A lbs.ai	Method of Application: pre-Plant	pre-emerg.	post-emerg.	Weed Control Rating[1]: nut-sedge	annual broadleaves	annual grasses	Ave.corn stand per acre[2]	Yield[3] Bu.at 1 moistur
1.	Eptam + 2,4-D	3 + 1-1/2	x	-	-	7	7	8	22,070	22
2.	Eptam + 2,4-D	4 + 2	x	-	-	9	7	9	19,166	32
3.	Eptam + Atrazine	3 + 1	x	x	-	9	10	10	20,909	45
4.	Eptam + Atrazine	3 + 1	x	-	x	9	10	9	20,522	37
5.	Eptam	3	x	-	-	8	7	9	20,134	23
6.	Eptam	4	x	-	-	8	6	10	21,102	26
7.	Eptam + 2,4-D	4 + 1	x	x	-	8	9	9	20,715	43
8.	R-1910 + 2,4-D	2 + 1	x	-	-	7	4	6	20,134	11
9.	R-1910 + 2,4-D	3 + 1	x	-	-	9	5	9	21,296	19
10.	R-1910 + 2,4-D	4 + 1	x	-	-	9	6	10	20,715	15
11.	R-1910 + 2,4-D	3 + 1-1/2	x	-	-	8	3	9	21,102	13
12.	R-1910 + 2,4-D	4 + 2	x	-	-	9	5	10	20,715	20
13.	R-1910	3	x	-	-	9	2	9	19,941	2
14.	R-1910	4	x	-	-	9	3	10	20,070	4
15.	R-1910 + Atrazine	3 + 1	x	x	-	9	10	10	23,426	44
16.	R-1910 + Atrazine	3 + 1	x	-	x	9	10	10	22,651	50
17.	R-1910 + 2,4-D	4 + 1/2	-	x	-	0	5	8	21,296	6
18.	R-1910 + 2,4-D	4 + 1	-	x	-	0	4	2	22,264	14
19.	R-1910	4	-	x	-	1	0	0	20,328	2
20.	Atrazine	1	-	-	x	0	9	6	22,264	28
21.	Atrazine	2	-	-	-	2	10	7	22,264	41
22.	Atrazine	3	-	-	x	4	10	8	22,458	30
23.	Check	2 cult.	-	-	x	6	6	6	20,715	12
24.	Check	no cult.	-	-	-	-	-	-	19,747	1

1 Values represent the average of 3 visual ratings made at approximately 6-week intervals during the growing seas June 30, August 10, and Sept. 21. Rating scale: 0=no control, 10=complete control.

2 Average corn stand represents the average number of corn plants per acre per treatment (4 replications) in the harvest rows.

3 Yield value is the average of 3 replications, expressed as bushels of shelled corn at 15 percent moisture.

Table 2

Chemical, Method of Treatment, Weed Control Rating, Plant Population, and Yield of Field Corn, Aurora Farm, 1964

Treat. No.	Chemical	Rate/A lbs.ai	Method of Treatment	Weed Control Rating[1] nut-sedge	annual broadleaves	annual grasses	Ave. corn stand per acre[2]	Yield/A Bu. at 15% moisture[3]
1.	Atrazine	3	preemergence	6	10	10	24,006	45
2.	SD-9796	5	"	1	1	0	22,070	9
3.	2,4-D ester	2	"	0	6	0	22,070	25
4.	SD-9813	5	"	1	1	0	21,296	6
5.	SD-9515	5	"	1	3	3	23,619	6
6.	SD-9515	7	"	1	3	0	22,651	16
7.	Linuron (50-W)	1-1/2	"	0	9	9	27,264	30
8.	Atrazine (80-W)	1-1/2	"	1	10	9	23,038	43
9.	Eptam + 2,4-D	4 + 2	"	0	8	0	22,651	30
10.	R-1910 + 2,4-D	4 + 2	"	0	8	0	22,844	29
11.	H-95-1	3	"	0	7	3	22,651	19
12.	H-95-1	4	"	1	8	5	27,070	25
13.	H-95-1 + Atrazine	2 + 1	"	3	9	9	23,813	35
14.	H-137	2	"	1	7	9	23,426	30
15.	H-137	3	"	1	8	6	22,070	21
16.	H-149	2	"	0	8	8	22,070	25
17.	H-149	3	"	0	9	9	23,619	34
18.	H-150	2	"	0	9	9	22,844	35
19.	H-150	3	"	3	9	9	21,102	29
20.	CP-31393	4	"	5	3	8	22,070	12
21.	CP-31393	6	"	8	5	9	23,232	16
22.	CP-31393 + Atrazine	3 + 1	"	2	9	9	22,651	35
23.	Check	2 cult.	postemergence	6	6	6	23,038	32
24.	Check	no cult.	-	-	-	-	22,845	2

1 Values represent the average of 3 visual ratings made at approximately 6-week intervals during the growing season: June 30, August 10, and Sept. 21. Rating scale: 0 = no control, 10 = complete control.

2 Average corn stand represents the average number of corn plants per acre per treatment (4 replications) in the harvest rows.

3 Yield value is the average of 3 replications, expressed as bushels of shelled corn at 15 percent moisture.

Table 3

Chemical, Method of Treatment, Weed Control Rating, Plant Population, and Yield of Field Corn, Aurora Farm, 1964

Treat. No.	Chemical	Rate/A. lbs.ai	Method of Treatment: Pre-emerg.	At emerg.	Post-emerg.	Weed Control Rating[1]: nut-sedge	annual broadleaves	annual grasses	Ave. corn stand per acre[2]	Yield/A. Bu. at 15 moisture[3]
1.	Amiben	3	x	-	-	1	4	6	24,394	16
2.	Amiben	4	x	-	-	0	6	8	23,426	18
3.	Amiben + Atrazine	1 + 1	x	-	-	0	9	9	23,813	43
4.	Amiben + Atrazine	2 + 1	x	-	-	1	9	9	21,683	24
5.	Amiben + Linuron	1 + 1	x	-	-	0	7	7	22,070	24
6.	Amiben + Linuron	2 + 1	x	-	-	0	9	8	22,070	25
7.	Amiben + CP-31393	2 + 2	x	-	-	0	4	5	22,845	7
8.	Amiben + CP-31393	2 + 3	x	-	-	1	6	7	20,522	14
9.	Atrazine + Linuron	1 + 1	x	-	-	1	9	9	23,232	29
10.	Atrazine + CP-31393	1/2 + 3	x	-	-	1	9	8	22,458	34
11.	Atrazine	2	x	-	-	3	10	9	23,813	46
12.	Linuron	1	x	-	-	0	7	7	23,232	18
13.	Linuron	2	x	-	-	0	9	9	22,845	29
14.	Niagara 7251	1-1/2	x	-	-	0	8	0	24,394	25
15.	Niagara 7251	2-1/2	x	-	-	1	9	5	23,038	31
16.	TH-052-H	4	x	-	-	0	4	3	21,877	10
17.	TH-052-H	6	x	-	-	0	5	6	20,522	19
18.	Falone + DN	2 + 1-1/2	-	x	-	0	8	1	21,102	21
19.	C-2059	2	x	-	-	2	9	9	21,296	34
20.	R-1910 + 2,4-D	3 + 1-1/2	x	-	-	0	8	1	22,458	29
21.	Eptam + 2,4-D	3 + 1-1/2	x	-	-	1	9	1	23,426	31
22.	Stam F-34	4.6	-	-	x	0	9	9	16,262	15
23.	Check	2 cult.	-	-	x	6	6	6	24,394	30
24.	Check	no cult.	-	-	-	-	-	-	21,877	2

1 Values represent the average of 3 visual ratings made at approximately 6-week intervals during the growing season: June 30, August 10, and Sept. 21. Rating scale: 0 = no control, 10 = complete control.

2 Average corn stand represents the average number of plants per acre per treatment (4 replications) in the 3 harvest rows.

3 Yield value is the average of 3 replications, expressed as bushels of shelled corn at 15 percent moisture.

Table 4

Chemical, Method of Treatment, Weed Control Rating, Plant Population, and Yield of Field Corn, Aurora Farm, 1964

Treat No.	Chemical	Rate/A lbs.ai	Method of Treatment	Weed Control Rating[1] nut-sedge	annual broadleaves	annual grasses	Ave. corn stand per acre[2]	Yield/A Bu. at 15% moisture[3]
1.	Linuron (50-W)	1	early post	0	9	8	21,683	34
2.	Linuron (50-W)	2	"	0	10	9	23,426	40
3.	Atrazine + oil (no w.a.)	1	"	0	9	9	23,038	48
4.	GS-11362	1	"	0	4	0	23,619	17
5.	C-2059	1-1/2	"	0	6	6	22,651	35
6.	C-2059	3	"	0	9	10	22,651	36
7.	Atrazine + Prometryne (50-W)	1 + 1	"	0	10	10	23,426	40
8.	Atrazine + Ametryne	1 + 1	"	0	10	9	23,426	34
9.	Atrazine + oil	1/2	"	0	9	8	24,006	36
10.	Atrazine + oil	1	"	0	10	9	22,845	38
11.	Atrazine + oil	1-1/2	"	0	10	9	23,619	39
12.	Simazine + oil	1/2	"	0	9	8	22,264	31
13.	Simazine + oil	1	"	0	9	9	23,619	33
14.	Simazine + oil	1-1/2	"	0	10	9	22,264	36
15.	Atrazine + Banvel-D	1 + 1/4	"	0	10	9	23,813	36
16.	Atrazine + Banvel-D	1 + 1/2	"	0	10	8	23,426	39
17.	Atrazine	1	"	0	9	8	22,651	34
18.	Atrazine	2	"	0	10	9	23,813	44
19.	Simazine	1	"	0	9	8	22,264	38
20.	Linuron (liquid)	1	"	0	9	9	21,683	33
21.	Linuron (liquid)	2	"	0	10	9	17,811	40
22.	Check	1 cult.	"	5	5	5	23,232	26
23.	Check	2 cult.	"	6	6	6	23,038	31
24.	Check	no cult.	"	0	-	-	21,877	7

1 Values represent the average of 3 visual ratings made at approximately 6-week intervals during the growing season: June 30, August 10, and Sept. 21. Rating scale: 0 = no control, 10 = complete control.

2 Average corn stand represents the average number of plants per acre per treatment (4 replications) in the 3 harvest rows.

3 Yield value is the average of 3 replications, expressed as bushels of shelled corn at 15 percent moisture.

Table 5

Chemical, Method of Treatment, Weed Control Rating, Plant Population, and Yield of Field Corn, Aurora Farm, 1964

Treat No.	Chemical	Rate/A. lbs.ai	Method of Treatment: pre-emerg.	Method of Treatment: post-emerg.	Weed Control Rating[1]: nut-sedge	Weed Control Rating[1]: annual broad-leaves	Weed Control Rating[1]: annual grasses	Ave. corn stand per acre[2]	Yield/A. Bu.at 15% moisture[3]
1.	Linuron	1	-	x	0	10	9	18,586	32
2.	Linuron	2	-	x	1	10	10	11,616	34
3.	Atrazine	1	-	x	0	10	8	22,428	44
4.	Atrazine	2	-	x	2	10	9	22,651	37
5.	Atrazine + 1 cult.+ Atrazine	1 + 1	-	x	4	10	9	23,232	44
6.	Linuron + 1 cult. + Linuron	1 + 1	-	x	1	10	10	18,586	47
7.	2 cult. + Atrazine	1	-	x	0	8	2	20,715	44
8.	Atrazine + Linuron	1 + 1	-	x	1	10	10	14,907	38
9.	Simazine + Linuron	1 + 1	-	x	1	10	9	19,360	27
10.	Atrazine + Prometryne	1 + 1	-	x	1	10	8	23,038	40
11.	Paraquat	1/2	-	x	0	9	7	17,424	23
12.	Banvel-D	1/4	-	x	0	8	0	22,070	12
13.	Banvel-D	1/2	-	x	0	9	0	21,296	12
14.	Banvel-D + 2,4-D amine	1/8 + 1/8	-	x	0	9	0	21,683	12
15.	Banvel-D + 2,4-D amine	1/4 + 1/4	-	x	0	10	0	21,296	12
16.	Banvel-D + Atrazine	1/4 + 1	-	x	0	10	2	20,522	30
17.	1 cult.+ Atrazine + 1 cult.	1	-	x	0	3	1	20,715	31
18.	Atrazine + Banvel-D	1-1/2 + 1/4	x	-	1	10	9	21,683	44
19.	C-2059	1-1/2	-	x	0	8	2	22,070	41
20.	C-2059	3	-	x	0	9	6	23,038	26
21.	C-2126	3	-	x	4	9	7	20,134	26
22.	Check	1 cult.	-	x	5	5	5	21,102	24
23.	Check	2 cult.	-	x	6	6	6	20,909	26
24.	Check	no cult.	-	-	-	-	-	21,683	7

1 Values represent the average of 3 visual ratings made at approximately 6-week intervals during the growing season: June 30, August 10, an Sept. 21. Rating scale: 0 = no control, 10 = complete control.

2 Average corn stand represents the average number of plants per acre per treatment (4 replications) in the 3 harvest rows.

3 Yield value is the average of 3 replications, expressed as bushels of shelled corn at 15 percent moisture.

FIELD PERFORMANCE WITH EPTC + 2,4-D [1]

IN FIELD AND SWEET CORN

Dante Marini and R. R. Libby[2]

In 1963, seven test locations were selected to evaluate in 1964 weed control with EPTC + 2,4-D in field and sweet corn under general farm conditions. These particular locations were selected based on a definite grass or broadleaf weed history over the past several years. These areas had varied soil type and were separated sufficiently to afford an evaluation of EPTC + 2,4-D (Knoxweed) herbicide activity during the 1964 growing season.

PROCEDURE

These seven tests, four in Maryland, and one each in Pennsylvania, Delaware and New Jersey, were conducted under general grower conditions. In all tests the growers prepared the fields following common practices and planted with commercial four-row corn planters. Stauffer Chemical Company's equipment and personnel were responsible for the application of the herbicide treatments. A 150 gallon John Bean weed sprayer with a 22 foot boom was used for the liquid applications and a 6 foot Gandy applicator was used for the granular applications. Plot sizes ranged from one to 20 acres with checks and replications carried out where practical. At three of the seven locations, Atrazine was compared and evaluated. All locations were observed bi-weekly up until harvest, with rainfall and cultivation records taken throughout the progress of the season. Yield information was available at four locations.

Test conditions, such as soil type, corn variety, number of days between planting and application, rainfall and weed problems, varied with each test. At all locations EPTC + 2,4-D was applied on the soil surface with no incorporation. A cultivation was made when the corn was 8-14 inches tall in four tests. At test sites No. 3 and No. 5, corn emergence was visible at the time of application. Rainfall for the growing season in all areas was below normal.

1. Knoxweed TM-Ethyl di-n-propylthiolcarbamate and Iso Octyl Ester of 2,4- Dichlorophenoxyacetic Acid, Stauffer Chemical Company.

2. Technical Sales Representative and Technical Representative respectively, Stauffer Chemical Company, New York, New York.

RESULTS

The accompanying chart describes the results of each trial individually. This method of data presentation was chosen to facilitate comparison of the various test conditions. Observations in numerous commercially treated plantings and other controlled experiments support the general findings in these seven selected controlled test sites. The conclusions drawn from this additional work, support and influence the statements made in this report.

DISCUSSION

Rainfall that followed the pre-emergence application definitely increased the activity of the surface applied EPTC + 2,4-D. In all areas where at least 2/10 inch rain fell within 1-14 days of application, control of both grassy and broadleaf weeds was good to excellent. However, satisfactory results were obtained in areas with an extended dry period after application if given a rotary-hoeing or light cultivation using sweeps within 6-12 days. Where rainfall occurred within 5 days, and no cultivation made, up to 90% control of all weeds was achieved. Increasing the rate of EPTC from 2 lbs. to 3 lbs. actual per acre, and holding the 2,4-D at 1 lb., did not give significantly better weed control. A special EF liquid formulation compatible with 30% liquid nitrogen, when mixed either in nitrogen or water gave 5% to 8% better control when compared to the standard liquid formulation mixed in water. Mixing and spraying of this EF formulation was excellent and trouble free in the nitrogen.

At four of the test locations, R-4910 + 2,4-D and R-1607 + 2,4-D at two plus one and three plus one ratios gave promising results. Trials with R-1910 + 2,4-D are planned for 1965.

SUMMARY

1. In all trials no injury occurred even where the corn had emerged at application.

2. Rainfall within 14 days is needed to obtain good commercial weed control. In the event no immediate rainfall occurs, a cultivation using a rotary-hoe or shallow set sweeps, has been efficient in achieving commercial weed control.

3. From these and other trials, it has been determined that a cultivation, when escape weeds are in the seedling stage and/or at lay-by, has increased performance consistency. This cultural program is recommended as an adjunct to the chemical treatment.

4. Comparative trials indicated that the granular 5-2 was slightly more effective when rainfall occurred within two weeks of application. These differences, however, were not significant.

5. In four areas where the standard rate of liquid was compared to Atrazine, superior grass control and higher yields were obtained.

6. Yields were consistently higher than the check and harvest efficiency was increased 15%.

7. In areas treated with EPTC + 2,4-D at either rate, and seeded to a fall cover crop germination and plant growth is normal.

8. In all cases the special EF formulation caused no mixing or sprayer problems. Control ratings showed it to be equally effective to the standard liquid formulation.

1. Comparative Chart of Seven Field Heads with EPTC + 2,4-D (Cont'd)

Main Weed Problems	First Rain After Application	Total Rain for 3 Months	Culti. After Application	% Control* Grasses Check	Grasses Treatments Liq.	Grasses Treatments Gran.	Bd. Leaf Weeds Check	Bd. Leaf Weeds Treatments Liq.	Bd. Leaf Weeds Treatments Gran.	Yield bu/a Check	Yield bu/a 2 lbs. EPTC + 1 lb. 2,4-D	Yield bu/a Atrazine
Velvetleaf, Fall Pannicum, Crabgrass, Ann. Morning-glory	17 days	6.2"	1 culti. when corn was 8" tall	2	8 4		3 ATRAZINE	9 5		87 bu	95 bu.	88 bu.
Foxtail, Crabgrass, Ann. Morning-glory	6 days	6.8"	1 culti, when corn was 8" tall	3	8 7		2 ATRAZINE	8 7				
Barnyard grass Velvetleaf Lambsquarter	5 days	4.7"	No culti, and one culti.	1	8	9	2	7	8	33.7 bu. 43.1 bu.	59.8 bu. 65.4 bu.	
Jimsonweed, Red-root, Pigweed, Ann. Morning-glory Foxtail, Ann. Crabgrass	4 days	4.2"	No culti.	4	9	9	1	9	10			
Giant Foxtail Lambsquarter	23 days	5.7"	1 culti. when corn was 12" tall	1	6 4		1 ATRAZINE	7 7		47 bu.	61. bu.	55 bu.
Barnyard grass Foxtail, velvetleaf	8 days	6.6"	1 culti. when corn was 12-14"	2	7		1	5		81 bu.	93 bu.	
Giant Foxtail Crabgrass, Lambsquarter, Purslane	15 days	4.9"	No culti.	1	8		2	6				

* 0-No Control 7-Commercial 10-(10%)

1. Comparative Chart of Seven Field Heads with EPTC + 2,4-D

Location	Soil Type & Moist. Content	Variety	Depth Planting	Planted	Treated	Material & Rate/Acre	Type of Treatment	Area Treated	Check	Corn Injury	Other Herbicid
Test 1 Cecilton, Md.	Sassafras Loam-(moist)	De Kalb 812	1 1/2"	May 30, 1964	June 30, 1964	2 lb. EPTC + 1 lb. 2,4-D Liq. EF	Broadcast	4 Acres	Bal. of 10/A field	0	Atrazine in Adj. f
Test 2 Earlville, Md.	Sassafras Loam (moist)	Iochief (sweet-corn)	1 1/2"	May 17, 1964	May 17, 1964	2 lb. EPTC 1 lb. 2,4-D Liquid	14" band	20 Acres	Middles	0	Atrazine bal. of f
Test 3 Galena, Md	Silty Clay Loam (moist)	Eastern States 800	2"	June 25, 1964	June 30, 1964	2 lb. EPTC 1 lb. 2,4-D Liq. & Gran.	Broadcast	2/A. Liq. 2/A. Gran.	2 row check between treatments	0	3 lb. EPT 1 lb. 2,4
Test 4 Crystal Beach, Md.	Clay loam (dry)	Pioneer 3166 MR	2"	June 27, 1964	July 1 1964	2 lb. EPTC + 1 lb. 2,4-D Liq. & Gran.	Broadcast	3 A/liq. 2 A/liq.	2 row check between treatments	0	Atrazine per acre acre fiel
Test 5 Woodstown,. N.J.	Clay Loam (dry)	New Jersey #10	2"	June 8, 1964	June 13, 1964	2 lb. EPTC + 1 lb. 2,4-D Liq. & Gran.	Broadcast	4 A/Liq. 2 A/Gran.	2 row check between treatments	0	Atrazine per acre acre fiel
Test 6 Dover, Del.	Silty Clay Loam (dry)	Pioneer #312 A	1 1/2"	May 21, 1964	May 25, 1964	2 lb. EPTC + 1 lb. 2,4-D Liquid	Broadcast	4 one acre Repli.	2 row check between treatments	0	None - One cultivatio
Test 7 West Chester, Pa.	Clay Loam (dry)	Northrup King (sweet corn)	1 1/2"	May 31, 1964	June 3, 1964	2 lb. EPTC + 1 lb. 2,4-D Liq. & Gran.	Broadcast	1 A/Liq. 1 A/Gran	Bal. of 15/A field	0	None - One Cultivatio

Herbicide Mixtures for Weed Control In Corn

Collins Veatch[1]

When atrazine has been used on corn in sufficient quantity to control perennial weeds the residue has often interferred with a normal rotation of crops.

The field trials in this report were conducted to test atrazine, combinations of atrazine with other herbicides and other herbicides in an attempt to find a combination that would give full season control of perennial weeds without leaving a residue harmful to subsequent rotation crops.

Materials and Methods

Herbicides were applied, at the indicated rates, to two row corn plots, pre-emergence and pre-emergence in combination with post-emergence as indicated in the Tables.

Yields were calculated on the basis of 15.5% moisture. The weed control index was based on 0 as no control and 10 as a clean weed free plot.

Samples of soil from the plots showing good weed control were taken at depths of 0" - 2" and 2" - 4" and potted in the greenhouse. The pots were then planted with Andrew oats as a biological test for herbicide residue. The assumption was made that there was no toxic herbicide residue present if weeds were present.

Discussion of Results

The yields of the Wardensville plots were limited by drought which also reduced the effectiveness of the herbicides as indicated in Table 1. The weed index recorded on June 22 carried through rather consistently to October 7. None of these treatments gave satisfactory control of the nut sedge. The plot treated with only one pound of atrazine per acre (check) gave a yield of 66.18 bu. of corn with a weed index of 5 while the highest yield was recorded from the plots treated with 1 lb. of atrazine plus 2 lbs. of Banvel D per acre with a weed index of 6. None of these plots were free of weeds which was considered to indicate that no appreciable herbicide residue was present. These plots were cultivated once on June 22.

The yields and weed indices of the plots treated with 1 lb. of atrazine pre-emergence plus a post emergence spray of the indicated herbicides at Wardensville are reported in Table 2. The highest yield in this trial 67.68 bu. per acre was harvested from the plots treated with 1 lb. of atrazine followed by a post emergence application of 2 lbs. of DNP. The best weed control was secured where the atrazine was followed by 2 lbs. of Lorox or 2 lbs. of Paraquat. Oats planted in the surface soil from the Lorox and Paraquat treated plots indicated a toxic residue in the Lorox treated plots but not in the Paraquat treated plots. Banvel D applied as a directed spray

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at 2 lbs. per acre apparently injured the corn. These plots were not cultivated.

The yields and weed control indices of the plots treated pre-emergence with 2 lbs. of atrazine, plus the indicated herbicides, at Reedsville are reported in Table 3. The highest yield, 141.58 bu., was secured with the combination of 2 lbs. of atrazine with 4 lbs. of caseron, however, the weed control was poor with an index of only 2.25. Only three combinations gave weed indices of 7.25 or higher, 4 lbs. of atrazine, 2 lbs. of atrazine plus 2 lbs. of Lorox and 2 lbs. of atrazine plus 3 lbs. of C.P. 31393. The surface soil from the plots treated with 4 lbs. of atrazine or 2 lbs. of atrazine plus 3 lbs. of C.P. 31393 both carried sufficient residue to kill oats. The Lorox atrazine combination was not tested in the greenhouse. The plots treated with 4 lbs. of prometryne carried no residue as indicated by the oat test but was rated with a weed index of only 5.5.

The Reedsville plots treated pre-emergence with 2 lbs. of atrazine with the intention of following with a directed spray were so free of weeds that the directed spray was never applied.

Similar combinations were tested at Pt. Pleasant as at Wardensville. However, the plots were so non-uniform, due primarily to drought, that no yields were taken on the plots. The oat test did not indicate any toxic residue in this sandy loam soil even where 4 lbs. of atrazine had been applied.

Summary

In the trials at Wardensville the combination of 1 lb. of atrazine with 2 lbs. of Banvel D pre-emergence gave slightly better yields and weed control than 1 lb. of atrazine alone.

The best weed control at Wardensville was secured with 1 lb. of atrazine pre-emergence plus post-emergence applications of either 2 lbs. of Lorox or 2 lbs. of Paraquat. The oat test indicated a toxic residue in the surface soil of the plots treated with Lorox but not in those treated with Paraquat.

At Reedsville the best weed control was secured with 4 lbs. of atrazine or 2 lbs. of atrazine plus either 2 lbs. of Lorox or 3 lbs. of C.P. 31393. The oat test indicated a toxic residue in the surface soil of the 4 lbs. atrazine and the C.P. 31393 combination treated plots. The atrazine Lorox treated plots here were not tested for residue.

I
Wardensville

Yields and weed control indices of plots sprayed pre-emergence with 1 lb. of atrazine per acre plus the listed herbicide at Wardensville.

Herbicide	lb./A.	bu./A.	Weed Control Index June 22	Weed Control Index October 7
Banvel D	2	70.13	5.0	6.0
Check	(1 lb. atrazine)	66.18	5.75	5.
2,4-D	1	64.23	5.75	5.75
Swep	2	61.70	5.25	5.25
Cyan. 51-911	2	60.63	3.75	4.5
Lorox	1	60.10	5.75	5.25
Prometryne	1	58.83	3.25	3.
Amiben	2	58.30	3.75	4.0
Ametryne	1	53.88	4.	4.25
Dalapon	2	53.73	2.75	2.25
Average		60.77		
$L.S.D._{.05}$		13.56		

Applied May 19, 1964

II
Wardensville

Yields and weed control indices of plots sprayed pre-emergence with 1 lb. of atrazine per acre plus a post-emergence directed application of the listed herbicide at Wardensville.

Herbicide	lb./A.	bu./A.	Weed Control Index October 7
DNP	2	67.68	5.5
Lorox	2	62.73	8.5
Paraquat	1	60.40	6.5
Prometryne	1	58.50	2.25
Ametryne	1	57.88	4.5
Paraquat	2	55.78	8.0
2,4-D	½	53.45	3.5
Niag. 7251	2	51.98	3.25
Check	No herbicide	42.58	0
Banvel D	2	38.83	3
Average		54.975	
$L.S.D._{.05}$		5.13	

Applied May 19 & June 22

III
Reedsville

Yields and weed control indices of plots sprayed pre-emergence with 2 lbs. of atrazine per acre plus the listed herbicide at Reedsville.

Herbicide	lb./A.	bu./A.	Weed Control Index October 9
Caseron	4	141.58	2.25
Lorox	2	139.68	7.25
Tenoran	4	124.98	6.75
C-2059	3	122.35	5.5
Cy. 51-911	3	121.7	3.75
*Prometryne	4	121.0	5.5
Dalapon	3	120.73	2.75
Atrazine	2	119.95	7.25
Niag. 7251	4	118.40	4.5
Check	No herbicide	111.65	.75
C.P. 31393	3	107.25	7.75
Ametryne	2	101.53	4.75
Banvel D	4	63.93	4.25
Average		116.52	
$L.S.D._{.05}$		31.18	

*Applied May 21, 1964
No Atrazine

Control of *Ipomoea purpurea* and *Ipomoea hederacea* In Soybeans with 2,4-D and 4-(2,4-DB)[1]

H. P. Wilson and R. H. Cole[2]

Many soybean fields in Delaware contain *Ipomoea purpurea* (L.) Roth. (common morning glory) and *Ipomoea hederacea* (L.) Jacq. (ivy-leaved morning glory). In 1957, Indyk (1) reported the weed population in the Newark test areas consisted almost entirely of morning glories. Annual tours of soybean fields in Delaware have shown that about one-third of the acreage in the state is infested with these two weeds. Competition for moisture, light, and mineral nutrients reduced yield; and lodged soybeans, resulting from entwined morning glories, make harvest operations difficult and in some cases impossible. Morning glory seeds present in grain from harvested fields reduce soybean quality and are difficult to remove because of their seed size.

Williams and Brown (2) have reported that the amine form of 4-(2,4-DB) applied at rates between 0.17-0.22 pounds per acre partially controlled morning glory in soybeans in the Mississippi Delta area. They indicate the herbicide should be applied during a period from 7-10 days prior to bloom of soybeans and extending through the mid-bloom stage.

Studies were initiated in 1962 in Delaware to determine if late post-emergence applications of amine forms of 2,4-dichlorophenoxyacetic acid (2,4-D) and 4-(2,4-dichlorophenoxy) butyric acid 4-(2,4-DB) could be used to control these two *Ipomoea* species.

Materials and Methods

Studies were conducted in 1962, 1963, and 1964 at the University Substation Division Farm, Georgetown, Delaware, on a Norfolk sandy loam soil and at the University Farm, Newark

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2. Research Fellow and Assistant Professor of Agronomy, University of Delaware, Newark, Delaware.

on a Matapeake silt loam soil in 1963 and 1964. Land was prepared in the conventional manner and recommended fertilization practices were followed. Bethel, Clark, and Delmar soybeans were planted in 36 inch rows at Georgetown on June 7, 1962, June 7, 1963, and May 22, 1964, respectively and Bethel and Clark soybeans were planted at Newark on June 13, 1963, and May 26, 1964, respectively. A randomized block design was used in 1962. This was changed for the remainder of the test to a split plot design with the presence and absence of morning glories representing the main treatments.

Plots were four rows wide and 20 feet long. There were four replications at each location. Herbicides were applied to the two center rows of each plot with a carbon dioxide plot sprayer at the rate of 50 gallons of spray per acre. The rate of 2,4-D amine and 4-(2,4-DB) amine was 0.2 pounds per acre and applications were made during the bud, early bloom, and mid-bloom stages of soybean growth. Soybean height, injury and lodging ratings, and morning glory control were recorded prior to harvest. To determine yield, soybeans were mowed with a Jari plot mower and threshed with a Swanson plot thresher.

Morning glory populations varied with the years and locations. They were rated high in Georgetown in 1962 and 1963 but increased to very high in 1964. In Newark the population was small in 1963 and the seeds were late germinating. Dry weather and a very small population of morning glories caused the abandonment of the Newark location in 1964.

Results and Discussion

It can be seen from Table I that morning glories had a variable effect on soybean growth and yields. This can be attributed to the different populations found in the experimental areas. The small population in Newark in 1963 had no effect on soybean height or lodging and reduced yield only slightly. A heavy population in Georgetown the same year significantly reduced yield and caused a slight increase in lodging while still not affecting soybean height. However, in 1964 at Georgetown, morning glories significantly increased lodging, decreased height, and reduced yields.

Excellent control of morning glory was obtained with 0.2 pounds of 2,4-D in 1962 and 1963 (Table II). Soybean injury (appearing as stem callouses and crooking of the stems) increased lodging and decreased height were observed in nearly

TABLE I. Effects of Morning Glory Infestations on Soybeans in 1963 and 1964. Results are averages of all chemical treatments and four replications.

	Georgetown 1963			Newark 1963			Georgetown 1964		
	Lodging[1] Score	Height Inches	Yield Bu/A	Lodging Score	Height Inches	Yield Bu/A	Lodging Score	Height Inches	Yield Bu/A
With morning glory	2.7	21	13.9	3.3	32	19.9	3.1	34	10.3
Without morning glory	2.4	21	17.7	3.3	33	22.8	1.9	42	22.5
Significance	N.S.	N.S.	*	N.S.	N.S.	N.S.	*	*	**

1. Lodging Score: 1 = no lodging; 5 = complete lodging, 100% of plants down.

TABLE II. Effects of 2,4-D and 4-(2,4-DB) on soybeans at .2 pounds per acre in 1962 and 1963. Results of all chemical treatments and four replications.

Stage Applied	Georgetown 1962			Georgetown 1963				Newark 1963		
	Control All Tests	Injury[1] Score	Yield Bu/A	Injury Score	Lodging[2] Score	Height Inches	Yield Bu/A.	Lodging Score	Height Inches	Yield Bu/A
2,4-D										
Bud	Excellent	3.3	17.5	4.6	4.9	20	3.8	4.6	25	11.1
Early Bloom	Excellent	3.7	21.3	4.7	4.4	18	7.0	4.4	27	13.4
Mid-Bloom	Excellent	4.0	23.8	2.2	1.3	22	19.4	3.3	27	18.7
4-(2,4-DB)										
Bud	Excellent	2.3	30.7	2.3	2.4	21	18.4	2.9	37	25.2
Early Bloom	Excellent	3.7	18.7	3.4	2.5	20	15.6	2.6	35	24.4
Mid-Bloom	Excellent	4.3	20.7	1.7	1.3	22	22.6	2.5	37	27.6
Check (with morning glory)	Very Poor	1.0	35.2	1.0	1.2	23	21.8	2.5	38	26.7
Check (without morning glory)	Excellent	-	-	1.0	1.0	22	25.5	2.4	38	31.6
L.S.D. @ .05	-	1.5	7.2	1.4	0.4	2	2.5	0.6	3	4.2

1. Injury Score: 1 = no injury; 5 = very severe injury.
2. Lodging Score: 1 = no lodging; 5 = very severe lodging, 100% of plants down.

every treatment. Since yields were also reduced significantly it was decided not to include this herbicide in the 1964 tests.

Excellent morning glory control was also obtained with 4-(2,4-DB) in all tests (Tables II and III). In 1962 significant injury was evidenced at all application dates and the yield was reduced below the yield of the check except when the application was made in the bud stage. Crop injury and lodging increased with application of 4-(2,4-DB). In 1963 yields were significantly less than the check in all treatments except when the application was made during mid-bloom.

The results obtained in 1964 differed from those of the previous years (Table III). No reduction in height occurred even though injury was visible in all plots receiving 4-(2,4-DB). Two interesting Morning Glories X Sprays interactions occurred. Lodging was significantly reduced in all plots containing morning glories when 4-(2,4-DB) was applied while the herbicide seemed to have little effect on the weed-free soybeans. The second Morning Glories X Sprays interaction appeared in the yield analysis. When 4-(2,4-DB) was applied in the early bloom stage in the presence of morning glories, soybean yields increased significantly. Weed-free plots receiving the herbicide yielded slightly less than the weed-free check. In 1962 the best results from 4-(2,4-DB) were obtained when application was made during the bud stage of soybean growth. The most effective time of application in 1963 was during the mid-bloom stage. Contrary to these results, applications of 4-(2,4-DB) in the early bloom stage of soybean growth was the most effective treatment in 1964. Only once during the three years of the study was the yield of a treated plot significantly higher than the yield of the weedy check.

Harvesting operations were facilitated by removing the morning glories by mid-bloom, but morning glory seeds which had been set before the application of 4-(2,4-DB) appeared in harvested soybeans. In other tests which are not reported in this paper, it has been found that a major portion of the yield-reducing competition occurs before the time this herbicide would be applied. Only under conditions of high morning glory infestations could the application of 4-(2,4-DB) be expected to increase soybean yields.

Summary

The possibility of using amine formulations of 2,4-D and 4-(2,4-DB) to control two species of *Ipomoea* in soybeans was investigated. By using a split plot field design it was learned that competition from morning glories causes significant yield

TABLE III. Effects of 4-(2,4-DB) on Soybeans at .2 pounds per acre in 1964 at Georgetown. Results are averages of all chemical treatments and four replications.

Stage Applied	Injury Score[1] Combined[3]	Lodging Score[2] With Morning Glory	Lodging Score[2] Without Morning Glory	Height Inches Combined[3]	Yield Bu/A With Morning Glory	Yield Bu/A Without Morning Glory
Bud	2.1	2.4	1.8	38	9.0	22.1
Early Bloom	2.4	2.2	2.0	39	14.4	20.8
Mid-Bloom	1.9	3.1	1.8	38	10.0	22.2
Check	1.0	4.6	2.2	37	8.0	24.9
L.S.D. @.05	0.4	0.6	N.S.	N.S.	4.7	N.S.

1. Injury Score: 1 = no injury; 5 = very severe injury.
2. Lodging Score: 1 = no lodging; 5 = very severe lodging, 100% of plants down.
3. Combined data, with and without morning glories.

reduction to soybeans. Results indicated that 2,4-D increased lodging, decreased height, caused injury, and reduced yield significantly.

Less severe but similar effects on the characteristics measured were evidenced with 4-(2,4-DB). The use of 4-(2,4-DB) may be warranted only in cases of severe morning glory infestations.

Acknowledgments

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 in this work.

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FACTORS AFFECTING THE TOLERANCE OF SOYBEANS TO TRIFLURALIN, R-1607 and AMIBEN[1]

S. R. Colby[2]

As with other crops, the tolerance of soybean plants to selective herbicides is relative. Many of the new herbicides are capable of injuring soybeans. Thus an understanding of the factors affecting crop tolerance is necessary to minimize the danger of crop injury. For example, depth protection by the soil is an important factor in the selectivity of many preemergence herbicides. Obviously factors such as depth of the crop seed in the soil, soil type, rainfall, and depth of herbicide incorporation may influence selectivity. While incorporation of preemergence herbicides such as EPTC and others increases their herbicidal effectiveness (2), there is also the increased possibility of crop injury (8).

The purpose of these investigations was to study some of the factors which might affect the tolerance of soybean plants to alpha, alpha, alpha-trifluro-2, 6-dinitro-N,N-dipropyl-p-toluidine (trifluralin) n-propyl di-n-propylthiolcarbamate (R-1607) and 3-amino-2,5-dichlorobenzoic acid (amiben). Watering levels, depth of planting of soybean seed, time of treatment (i.e. immediate vs. delayed preemergence), and soil type were some of the factors investigated.

Materials and Methods

Investigations were carried out in the greenhouse in plastic pots. Five or six soybean (*Glycine Max* L. Merr.) plants per pot of the variety Ogden were grown in sandy loam soil. However, in one experiment with amiben three soil types were used. Soybean seed were planted 1/2 inch deep in the soil except in one study on the effect of seeding depth on crop tolerance. All herbicides were applied as preemergence sprays in 100 gpa of water. Herbicide sprays were applied either (1) to the soil surface or (2) directly to the soybean seed after sowing or (3) 1/4 to 1/2 inch below the soybean seed before sowing. Surface applications of herbicides were covered with 1/8 inch of sand to minimize herbicide losses due to volatility or ultraviolet light destruction. Normally plants were watered daily or as needed. Heavy watering consisted of 1/4 inch of water per day per pot; light watering was the minimum necessary to prevent wilting. Reduction in the fresh weight of soybean plants two to three weeks after spraying provided a measure of herbicidal injury.

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Results and Discussion

Rainfall and soil moisture levels are critical factors affecting the performance of many preemergence herbicides. Rainfall or moisture may be necessary to move the herbicide into the germination zone of the weeds. On the other hand high soil moisture levels may increase volatility losses of herbicides such as EPTC due to shielding or competitive effects at adsorption sites in the soil (7). Heavy rainfall may leach highly water soluble herbicides such as amiben out of the germination zone of weeds and reduce weed control (10) or worse yet injure crops with insufficient tolerance.

The effect of heavy and light watering on the tolerance of soybean plants to trifluralin, R-1607 and amiben is shown in Table 1.

Table 1. Effect of heavy and light watering on the tolerance of soybean plants to trifluralin, R-1607 and amiben. Herbicides were sprayed directly on the seed at planting time. Three weeks later fresh weights were taken.

		Fresh weight of soybean plants (% of controls)	
Herbicide	lb/A	Heavy watering	Light watering
Trifluralin	2	65	84
R-1607	6	57	102
Amiben	6	49	98
LSD 5%, 19			

Herbicides were sprayed directly on the soybean seed at about twice the rate recommended for weed control. Heavy watering increased injury to soybean plants by all three herbicides. Furthermore all herbicides produced severe injury at the heavy watering level indicating that depth protection is a factor in the selectivity of each. These results assume practical significance in view of the increased emphasis on the need for incorporating preemergence herbicides with the soil. Incorporation could result in herbicide placement in close proximity to the crop seed. Herbicide injury might then depend on the pattern of rainfall as well as on crop tolerance. Cole (3) has reported soybean injury by trifluralin and R-1607 when the herbicides were placed close to the seed.

Certain cultural practices might be expected to reduce the risk of crop injury when depth protection is involved in preemergence herbicidal selectivity. As shown in Table 2, increasing the depth of planting of soybean seed reduced injury by amiben but not by R-1607 or trifluralin. However, the latter two herbicides were in general, less injurious than amiben when soybean seed were planted shallow. Herbicides were applied on the soil surface in this experiment and covered with 1/8 inch of sand. Amiben has a greater water solubility than

trifluralin or R-1607, and this may be part of the reason why depth protection is so important with this herbicide. Careful control over depth of planting of seed may be helpful in avoiding crop injury by amiben in the field.

Table 2. Effect of depth of planting of soybean seed and time of herbicide treatment on the tolerance of soybean plants to trifluralin, R-1607 and amiben. Herbicides were sprayed on the soil surface and were covered immediately with 1/8 inch of sand.

		Fresh weight of soybean plants (% of controls) with herbicides applied			
		At planting		Two days after planting	
		Depth of soybean seed		Depth of soybean seed	
Herbicide	lb/A	1/8 in.	1/2 in	1/8 in.	1/2 in.
Trifluralin	2	86	84	72	79
R-1607	6	88	80	92	83
Amiben	6	61	78	62	89

LSD 5%, 15

There was a trend, although not statistically significant at the 5 percent level, towards greater injury by R-1607 when the soybean seed were planted deep. Previous research has shown that the shoot is the primary site of uptake of thiolcarbamates (4,5). Thus when soybean seed are planted deeply, the emerging shoots suffer a prolonged exposure to the herbicide.

Research at this experiment station by the author has shown that the primary site of uptake of amiben by soybean plants is the roots. Amiben injured soybean plants only when a high concentration was available to the roots. Since amiben is applied to the soil surface, it must be leached into the root zone to produce injury. Soil type influences leaching of amiben (6), and the risk of crop injury is greater on sandy soils. Once amiben has been leached into the root zone of soybean plants, the question arises, "Will injury still vary with the soil type"? To answer this question amiben was applied under the soybean seed in three different soil types[1]. The soil types were a Sharkey clay, a Wehadkee Silt Loam and a Lakeland Sandy Loam. Some of the characteristics of

[1] The soils and their characteristics were furnished by C.I. Harris, CRD, ARS, USDA, Beltsville, Maryland.

these soils are shown in Table 3.

Table 3. Characteristics of three soil types.

Soil type	pH	Total clay %	Organic matter %	Cation exchange capacity (meq/100g)
Sharkey Clay	6.2	67.1	3.9	40
Wehadkee Silt Loam	5.6	25.2	1.9	10
Lakeland Sandy Loam	6.2	10.5	3.3	3

Amiben was sprayed on each soil at 0, 3, and 9 lb/A and was covered with 1/4 to 1/2 inch of the same soil type. The soybean seed were then planted and covered with 1/2 inch of sand. Thus the herbicide was deliberately placed in the soil where it could produce the greatest injury to soybean plants.

As shown in Table 4, soybean injury by amiben varied with soil type as well as with rate of application. At 3 lb/A amiben injured soybean roots only on the silt loam soil. Actually 3 lb/A stimulated root growth on the clay and sandy loam soils. Nine lb/A of amiben injured soybean roots on all soil types, but the injury was less severe on the sandy loam soil than on the others. The response of shoots was similar to that of roots except that at 3 lb/A of amiben there was no difference from the control on the clay and sandy loam soils. The data for shoots are not shown.

Table 4. The effect of soil type and rate of application on amiben injury to soybean roots. Amiben was applied 1/4 to 1/2 inch under the soybean seed. Fresh weights of soybean roots were taken three weeks later.

Soil Type	Fresh weight of soybean roots (grams) with amiben rates (lb/A) 0	3	9
Sharkey Clay	.54	.83	.27
Wehadkee Silt Loam	.60	.28	.22
Lakeland Sandy Loam	.65	.85	.54

LSD 5%, .19

Stimulation of root growth by amiben is not surprising; Ascheman (1) previously reported growth stimulation by low concentrations of amiben. Possibly the fact that amiben did stimulate root growth indicated that only low

concentrations of the herbicide were biologically available in the clay and sandy loam.

Inhibition of root growth by 3 lb/A of amiben was more closely related to the organic matter content of the soil than to clay content or cation exchange capacity. This is not too surprising since the amiben molecule has little resemblance to a cation. Both the sandy loam soil and the clay soil had a higher organic matter content than the silt loam soil (Table 4). Warner (9) reported that the organic matter content of the soil was more important than the clay content or soil pH in inactivating the biological activity of amiben. He also found that organic matter was more closely correlated than clay content with the loss in radioactivity from soils treated with amiben-C^{14}.

On the basis of organic matter content, it is difficult to explain why the 9 lb/A rate of amiben produced more injury on the clay soil than on the sandy loam. Perhaps the organic matter is of a different type in these two soils. Possibly leaching of amiben was more important in the sandy loam than in the clay soil, and this may have reduced the amiben concentration near the germinating soybean seed. From measurements of root length, it was clear that soybean injury was avoided when the roots were able to grow into the soil below the zone where amiben had been applied.

Summary and Conclusions

1. Factors affecting the tolerance of soybean plants to trifluralin, R-1607 and amiben were studied in the greenhouse.

2. Heavy watering increased injury to soybean plants by all three herbicides.

3. Increasing the depth of planting of soybean seed reduced injury by amiben but not by trifluralin or R-1607. However, the latter two were less injurious than amiben when the seed were planted shallow.

4. Organic matter content of the soil was more important than clay content or soil type per se in preventing injury to soybean plants by 3 lb/A of amiben.

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FIELD PERFORMANCE OF R-1607 [1]

ON SOYBEANS

Dante Marini and R. R. Libby [2]

Soybean acreage continues to increase annually and one of the main production problems is weeds. This is generally true throughout the U. S. and Canada. Thus, in 1964 R-1607 6E and R-1607 5 Granular were applied to soybeans and evaluated on a commercial field scale. Plots sites were slected in fields with a high weed history in southern New Jersey, Delaware and Maryland.

PROCEDURE

One major soybean location on the Eastern Shore at Galena, Maryland was chosen for a portion of this work and the tests from this area representative of general results are cited here to illustrate performance of R-1607. In 1963 at this location, over 80 acres of soybeans were lost to weeds, suggesting an ideal testing area for 1964. Also a test at the University of Delaware, Sub-station, Georgetown, Delaware is described because of the weed species and in particular annual morning-glory. Comments on other test plots are added to substantiate an observation.

At all test sites the fields were prepared by the growers and planted with a commercial four row planter. R-1607 at 2 lbs. and 3 lbs. per acre was applied in both liquid and granular form at three main stages of soybean development.

1. Preplant
2. Post seedling - pre-emergence
3. At first rotary-hoeing when soybeans were 1" to 2" high

Equipment and personnel of Stauffer Chemical Company were used to apply the herbicides. A 150 gallon John Bean weed sprayer with a 22 ft. boom was used for liquid formulations and a 6 ft. Gandy applicator was used for granulars. Plot sizes ranged from ½ to 2 acres, with 4 row checks between each herbicide treatment. All treatments were applied broadcast,

1. Vernam TM for n-propyl di-n-propylthiolcarbamate - Stauffer Chemical Company

2. Technical Sales Representative and Technical Representative Stauffer Chemical Company

with incorporation and additional cultivations being made with standard farm equipment. (See chart for particular equipment used on each trial) All treatments were observed weekly through the first 6 weeks and then bi-weekly through the balance of the season. Rainfall records were kept throughout the growing season. In all test areas, total rainfall was off 48% from normal.

Rain occurrence:	July:	3.7"	
	August	1.83"	
	Sept.	2.77"	
	Oct.	1.29"	
	Total	9.59"	Normal 16.70"

However, weed competition was heavy and caused significant yield reduction in these plantings:

TEST CONDITIONS

The soil type was a Sassafras Silt Loam. At all locations the soil surface was loose and dry down to a depth of 1" to 2". The air temperature ranged from 85° to 94° during application of the chemicals. One exception to this occurred during the post seeding pre-emergence stage where a heavy rain made the soil moist and the surface became crusted. Taking advantage of this situation part of the field was rotary-hoed 3 to 4 hours before application to loosen the soil surface and hasten drying, thus, giving a comparison between a crusted, moist soil and a pre-worked loose, dry soil.

At all locations the beans were planted to a depth of 1½". Emergence of the soybeans was somewhat slower than normal due to the dryness, however, a uniform stand occurred throughout.

RESULTS AND DISCUSSION

Increase yields were recorded in all R-1607 plots regardless of application time. Where no additional cultivations were given from the time of herbicide treatment, in row plantings, yields increased 35-40% over the uncultivated check areas. However, if one cultivation was given to both checks and treated areas, when the soybeans were 8-10" tall, the herbicide treated areas showed a 15% to 20% increase in yields. And where R-1607 was applied pre-plant to broadcast planted soybeans an increase of yield of 42% over the untreated areas was recorded.

At two locations, hand weeded plots had yields equal to the treated areas. It should be noted, however, that these hand-weeded checks did not out-yield the treated plots thus,

it is highly improbable that the early cupping induces yield reduction.

Finally the efficiency to harvest was increased in the treated areas by 21.3% over the cultivated and uncultivated checks. This was true in both the row and broadcast planting.

It is definitely felt that the dry weather and the surprisingly high weed population in the untreated areas induced the tremendous yield differences.

In consideration of weed control R-1607, both 2 lb. and 3 lb. rate, applied post seeding and pre-emergence to the soybeans required an additional cultivation to give seasonal weed control. An effective time for this cultivation is when the beans are 8 - 10 inches tall. If the soil was wet and crusted at the time of herbicide application, weed control was greatly reduced regardless of means of incorporation employed. This is the expected results with any thiolcarbamate.

A number of good common grower tools are generally available and effectively incorporate R-1607 post-seeding pre-emergence.

1. Gandy row-wheel good when the herbicide applicator is attached to the planter.

2. Rotary-hoe (cup type preferred)

3. Potato Weeder

4. Spike tooth drag

R-1607 at the first rotary-hoe, soybeans 1" to 2" stage, proved a superior time for application. In test areas where 2-3# A/acre was used, either liquid or granular and received no cultivation control was 60-70% and with one cultivation, when the soybeans were 8-10 inches, resulted in 95-98% control until harvest. A rotary-hoe, potato weeder and light cultivation with sweeps were all used and proved to be satisfactory means for incorporating R-1607 at this time. Thus, these common tools serve the needs of incorporation at either post-plant recommendation.

At all these test sites incorporated EPTC granular and surface applied EPTC+2,4-D were also evaluated. Results with EPTC+2,4-D showed promise and investigations for next year are planned. Severe injury with EPTC was noted, as in the past.

R-1607 was also evaluated at the University of Delaware Sub-station at Georgetown, Delaware on a very light sandy soil. The material was applied post-seeding, pre-emergence and incorporated with a rotary-hoe. Both the 2 lb. and 3 lb.

The main weeds present were redroot pigweed, crabgrass, annual morning-glory, lambsquarter and purslane. R-1607 gave 80% to 90% control of all weed species up until harvest. No early cupping of the leaves was occurred.

One commercial application using R-1607 banded was observed throughout the growing season. At the farm of F. Doege, East of Cambridge, Maryland, R-1607 at 3# A/acre was applied post-seeding on 24 acres. Application was a 14 inch band two days after planting and incorporated immediately using a rotary-hoe set to run backwards. A ½" rain fell 40 hours after application and one cultivation was also employed when the soybeans were 8". Common and giant foxtail were the main problems and R-1607 gave 92% to 95% control of both species of foxtail right up until harvest. No early injury to the soybeans was observed here either.

SUMMARY

1. R-1607-treated plots had significantly higher yields over the check areas when properly applied either post-seeding, pre-emergence or at the first post-emergence cultivations.

2. R-1607 plus one cultivation when the soybeans were 8" to 10" tall gave seasonal weed control until harvest regardless of application time. This cultural practice is recommended with R-1607.

3. Excellent control of annual morning-glory occurred again this year.

4. R-1607 allowed for normal cover crop emergence and establishment where seeding occurred twelve weeks after application regardless of cover crop.

5. Rotary-hoe, Gandy row-wheel and potato weeder are tools that can be effectively used for incorporation post-seeding pre-emergence or at first post-emergence cultivation.

6. Double discing at right angles is the preferred way to incorporate R-1607 when it is being applied pre-plant.

7. Plant injury, persisting generally for only several days was observed when R-1607 at 2 and 3# A/acre was applied pre-plant. Further work on this time of application is being considered to determine annual safety. Presently, only post-seeding applications are recommended. A delay in seeding of 6-10 days may be desirable and effective in significantly reducing plant injury which this year, in our pre-plant treatments was quite light and quickly disappeared.

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1. Comparative Chart of Six Test Areas with R-1607 in Galena, Maryland

Herbicide	Form	Rate	Plot Size	Variety	Date of Planting	Date of Treatment	Type of Treatment	Incorp. Method	First Rain	12 Wk. Total Rain
R-1607	5% Gran.	2 lb/A	1/2 acre	Kent	6/30/64	6/25/64	Preplant broadcast: Soybeans also planted	Discing one way	7/3 2/10"	8.30 Same
Do	5% Gran.	3 lb/A	1/2 acre	Do	6/30/64	6/25/64				
Do	5% Gran.	2 lb/A	1 acre	Kent	6/26/64	6/25/64	Preplant broadcast: Soybeans planted on 32" row	Discing one way	7/3 2/10"	8.30 Same
Do	5% Gran.	3 lb/A	1 acre	Do	6/26/64	6/25/64				
Do	6E	2 lb/A	1 acre	Kent	6/26/64	6/25/64	Preplant broadcast: Soybeans planted on 32" spacing	Discing one way	7/3 2/10"	8.30 Same
Do	6E	3 lb/A	1 acre	Do	6/26/64	6/25/64				
Do	6E	2 lb/A	1 acre	Do	6/9/64	6/13/64	Post-seeding broadcast: Soybeans not yet emerged	Discing one way	7/13 3/10"	6.99 Same
Do	6E	3 lb/A	1 acre	Do	6/9/64	6/13/64				
Do	5% Gran.	2 lb/A	1 Acre	Kent & Dorman	6/26/64	7/7/64	Broadcast Post-emer: Soybeans at 1-2" height	Potato Weeder	7/3 2/10"	8.30 Same
Do	5% Gran.	3 lb/A	1 Acre	Dorman	6/26/64	7/7/64				
Do	6E	2 lb/A	1 Acre	Dorman	6/26/64	7/7/64	Broadcast Post-emer: Soybeans at 1-2" height	Potato Weeder	7/3 2/10"	8.30 Same
Do	6E	3 lb/A	1 Acre	Do	6/26/64	7/7/64				

1. Comparative Chart of Six Test Areas with R-1607 in Galena, Maryland (Cont'D)

Additional Cultivations	Soybean Injury from Herbicides	Weeds Present	Percent Control at 6 Weeks Grasses	Percent Control at 6 Weeks Broadleaves	Percent Control at 12 Weeks Grasses	Percent Control at 12 Weeks Broadleaves	Herbicides	Yield/bu/acre Adjacent Check
None	Slight leaf curling when beans 2-4" for 4-7 days	In all these test areas the major problem was barnyard grass. Also present was foxtail purslane, velvetleaf, lambsquarter, red-root pigweed and crabgrass. Percent control was evaluated against check areas.	9	9	8	7	19	11.2
Do			10	9	9	8	20.5	11.2
None	Same		8	9	6	6	18	12.2
Do			9	9	7	8	21.1	12.2
None	Same		8	9	6	6	17.2	12.2
			8	9	6	7	19.6	12.2
4 rows in 2# rate at 8-10" height	None		9	9	6/8*	6/9*	16.6	11.1
			9	10	7	8	17.4	11.1
Same as above	None		9	9	8/9+*	7/9+*	18.1	10.9
			10	10	8	8	19.0	10.9
Same as above	None		8	9	7/9+*	7/9+*	18.0	10.9
			9	10	7	8	18.2	10.9

* Control in 4 cultivated rows

0-No Control 7-Commercial 10-Perfect

THE EFFECT OF TRIFLURALIN ON SEVERAL CROP SPECIES[1]

R. W. Feeny and R. H. Cole[2]

Trifluralin (a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) is a relatively new herbicide which has U.S.D.A. label approval for pre-emergence application in soybeans. Full season control of grass and broadleaf weeds has been obtained in field tests and limited commercial use. It is probable that this chemical will find widespread use for soybean weed control in Delaware. Trifluralin applied to the soil at 2 pounds active material per acre has produced substantial injury to oats planted 1 year after the herbicide application.

Two of the common crop rotations used in Delaware are corn, small grain, late soybeans, and a cover crop; or corn, cover crop, soybeans, and a cover crop. A program of continual soybeans is very popular. The cover crops used are usually selected from the following: rye, wheat, ryegrass, barley, oats, crimson clover, or vetch. With the possibility of chemical carryover to the fall cover crop, or the following year's crop, the susceptibility of certain plant species to trifluralin should be studied. These plants may differ greatly in susceptibility to trifluralin as has been demonstrated with Atrazine and several oat varieties (1). Differences in plant tolerance could be responsible for stand reductions of the cover crop or the success or failure of the crop grown the following year. For these reasons the plant species susceptible to trifluralin injury become of great economic importance in the choice of the crop used.

Procedure

This study was conducted at the University of Delaware Substation Division Farm in Georgetown, Delaware, on Fallsington sandy loam. Trifluralin emulsifiable concentrate was applied

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2. Graduate Assistant and Assistant Professor of Agronomy, respectively.

at the rates of 1, 2, and 6 pounds active ingredient per acre to 10 by 20 feet plots. Each treatment was replicated twice. Applications were made with a hand CO_2 plot sprayer at a rate of 50 gallons of spray to the acre. Immediately after the herbicide application the treated soil was rototilled to a depth of 3 inches with a Jari hand rototiller. Crop species were planted at recommended depths in single rows 10 feet long with a hand-operated Planet Junior the same day that the herbicide was applied. Approximately equal numbers of seeds were planted in each plot. Table I lists the crop species used.

TABLE I. Variety or Seed Source and Scientific Name of Species Used in this Test.

"Balbo" Rye	*Secale cereale* L.
Commercial Ryegrass	Mixture of annual and perennial *Lolium spp.*
"Wong" Barley	*Hordeum vulgare* L.
"Clinton" Spring Oats	*Avena spp.*
"Dubois" Winter Oats	*Avena sativa* L.
"Seneca" Winter Wheat	*Triticum aestivum* L.
Commercial Crimson Clover	*Trifolium incarnatum* L.
"Hungarian" Foxtail Millet	*Setaria italica* (L.) Beauv.
Commercial Winter Vetch	*Vicia villosa* Roth
Commercial Spring Vetch	*Vicia sativa* L.
Commercial Canada Field Peas	*Pisum arvense* L.
"Wabash" Soybeans	*Glycine max.* (L.) Merr.
"Clark" Soybeans	Glycine Max. (L.) Merr.

Herbicide applications and plantings were made on June 15, 1964. The soil moisture at planting time and during the entire growing season was very low. For this reason, the test was irrigated on July 1, 1964, with 1/2 inch of water, and on July 7 with 1-1/2 inches of water. Plots were hand weeded three times to reduce the competition from undesirable plants. Visual stand notes were taken on July 10, August 6, and August 20, 1964. The green plants (with the exception of soybeans) were cut at the ground level on August 20, 1964, and placed in bags. The green forage was dried in a forced-air drier at 120°F. for 70 hours. The dry weights were then determined. The soybeans were harvested for grain yield on October 23, 1964.

Results and Discussion

Results are summarized in Tables II and III.

While an attempt was made to eliminate weed competition the number of early weeds present was apparently sufficient to reduce yields. Although this was noted with several plots, it was most evident in the crimson clover plot where reduced growth was found in the check plots as compared with the herbicide treatments.

Over all, the leguminous plants showed a greater tolerance to the application of trifluralin than did the gramineous plants. There was a considerable difference in tolerance between the gramineous species as can be seen when the dry weights and stand ratings of ryegrass and Hungarian millet are compared with those of wheat and barley.

Soybeans were very tolerant to high rates of trifluralin applications. There was no significant reduction in stand or grain yields with the 6 pound treatment. The ryegrass and millet showed very little tolerance to the lowest rate of trifluralin applied. Rye, barley, and wheat exhibited considerable tolerance to high rates of trifluralin. Of the two oat varieties tested Clinton seemed to have a lesser susceptibility to injury from the chemical, although this may have been due to the season in which the seeds were planted. Crimson clover was not greatly affected by moderate rates (1 and 2 pounds) of trifluralin and should be considered in future tests on trifluralin treated soils. The two vetches used showed tolerance at the moderate rate of 1 and 2 pounds. Canada field peas were not significantly affected by the 1 or 2 pound rates of application.

TABLE II. Effect of Trifluralin on the Yield of Plant Species

Crop	Trifluralin application in pounds active per acre			
	0	1	2	6
	Dry Weights in Grams[1]			
Rye	215 a[2]	170 ab	104 ab	74 b
Ryegrass	70 a	5.5 b	.5 b	0 b
Barley	131 a	70.25 b	63.5 b	45.5 b
Oats (Clinton)	107.5 a	74 a	61 ab	0 b
Oats (Dubois)	126 a	10 b	8.5 b	6.75 b
Wheat	28.5 a	25 a	26.5 a	19.5 a
Crimson Clover	20 a[3]	108.25 a	118.5 a	26 a
Foxtail Millet	475.5 a	119 b	0 b	0 b
Winter Vetch	125 a	105.5 a	76 a	15.25 a
Spring Vetch	134 a	157.5 a	111.5 ab	35 b
Canada Field Peas	193 a	195 a	182.5 a	70.5 b
	Soybean Yield Bu./A[1]			
Soybean (Wabash)	19.2 a	22.2 a	24.5 a	23.6 a
Soybean (Clark)	19.9 a	20.2 a	27.0 a	22.1 a

1. Results are the average of 2 replications.
2. Within any one row, means followed by the same letter do not differ significantly at P = .05.
3. Inability to eliminate early weed competition resulted in reduced yields for this species in both replications.

TABLE III. The effect of Trifluralin on Crop Stand

Crop	CROP STAND VALUES[1] Trifluralin Application in Pounds Active per A			
	0	1	2	6
Rye	10.0 a[2]	7.7 b	4.5 c	2.7 d
Ryegrass	8.2 a	.5 b	.2 b	0.0 b
Barley	8.8 a	7.2 ab	5.8 b	3.0 c
Oats (Clinton)	7.2 a	3.5 b	3.0 b	0.0 c
Oats (Dubois)	7.0 a	.8 b	.5 b	.7 b
Wheat	7.3 a	3.3 b	2.8 b	1.8 b
Crimson Clover	8.8 a	8.8 a	8.5 a	5.7 b
Foxtail Millet	9.3 a	1.7 b	.7 bc	.2 c
Winter Vetch	8.7 a	7.3 a	2.7 b	.8 c
Spring Vetch	9.3 a	9.5 a	7.0 b	2.2 c
Canada Field Peas	9.3 a	8.5 ab	7.5 b	2.3 c
Soybean (Wabash)	10.0 a	9.7 a	9.8 a	9.3 a
Soybean (Clark)	10.0 a	9.8 a	9.8 a	9.2 a

1. Stand scale from 0 to 10. 0 = no stand, 10 = complete stand. Results are the average of 2 replications and 3 dates.

2. Within any one row, means followed by the same letter do not differ significantly at P = .05.

Summary

This study represents an evaluation of several crop species as affected by trifluralin. Rye, barley, and wheat show considerable tolerance to trifluralin injury, and should be considered in future tests as crops to be planted in areas where trifluralin residue is expected. Ryegrass and Foxtail millet are very susceptible to trifluralin injury and should not be used where a chemical residue is possible. The use of these 2 species in detecting the presence of trifluralin residue is suggested. The oats species tested exhibited moderate to low tolerance, Clinton being the variety which showed a lesser degree of injury.

The leguminous plants tested in this experiment were rather tolerant to trifluralin injury. The 2 soybean varieties used were not significantly affected by 6 pounds of trifluralin in this test.

The susceptibility of the cover crops and the crops used in the normal rotation to trifluralin should be studied in detail to assure minimum damage from persistence of this herbicide in soils.

Acknowledgment

The authors wish to acknowledge the assistance of Eli Lilly and Company in making available the material used in this test and thank them for their continued interest in this work.

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PRE-PLANT AND PRE-EMERGENCE TREATMENTS OF HERBICIDES IN SOYBEANS

W. H. Tharrington, R. D. Ilnicki, J. F. Ellis and Lii-Chyuan Liu[1/]

Perhaps the most important single factor limiting yields of soybeans is weeds. The herbicides which are currently used have not been consistently effective on broadleaves and grasses. Furthermore, the rain-free periods usually following applications of herbicides, as evidenced in the past three years, have not been favorable to the performance of pre-emergence herbicides. Work has been underway here at this Station for the past five years to evaluate the performance of many herbicides. The investigations reported here are those of the past two years in which methods of application and the performance of promising herbicides will be discussed.

Materials and Methods

Experiments on soybeans were conducted at the Adelphia Research Center of the New Jersey Agricultural Experiment Station. Details of the experiment such as treatments, varieties used, dates of planting, application, ratings, and harvests, and soil type are presented in Tables 1 through 5 for the years 1963 and 1964.

Spray applications were applied with a plot or knapsack sprayer in water dilutions calibrated to deliver 40 gpa. Granular preparations were applied with a hand applicator using weighed amounts for each plot. Pre-plant applications were made to designated plot areas and incorporated with a spring-tooth harrow to a depth of 3-4 inches. Pre-emergence treatments requiring incorporation were made using a potato rake to simulate a harrow or rotary hoe.

All experiments were designed as randomized blocks with three or four replications.

Ratings of weed control and crop response were made by two or three individuals using a scale of 0 to 10 as indicated in the footnotes of the tables.

The center two rows of the four-row plots were harvested for yield determinations and yields calculated in bushels per acre.

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Results and Discussion

Summaries of weed control, crop response, and yields are presented in Tables 1 and 3 for the pre-plant soil incorporated experiments. A similar summary for the same herbicides applied pre-emergence is presented in Table 2. From these tables it can be seen that R-1607, EPTC, and trifluralin can be successfully used as either pre-plant or pre-emergence treatments. Rates of trifluralin greater than 2 lb/A are necessary if no incorporation is practiced.

Both R-1607 and EPTC are effective as pre-plant or pre-emergence treatments but these herbicides must be incorporated into the soil surface for maximum herbicidal efficiency. In Table 2 are presented summaries of identical rates of these two herbicides applied pre-emergence. Crop response and weed control data for the liquid and granular preparations of these two herbicides are also summarized here. Weed control was slightly better where the treatments were incorporated. This is especially true for R-1607. Generally, weed control from pre-emergence spray applications is superior to that obtained from granular applications; however, this difference was not apparent with EPTC in 1963.

With regard to crop injury and weed control, liquid sprays are safer and effect greater weed control than granulars when applied as pre-plant soil-incorporated treatments. This parallel was especially true for EPTC as evidenced in Table 1. This relationship was not true for R-1607, the liquid and granular treatments effecting equally good weed control with no significant differences in crop injury. In 1964, the degree of weed control with R-1607 was slightly greater from the granular than from the spray treatments, but the injury from the granular was still greater (Table 3). Whether this slight loss in herbicidal activity was contributed in part by the use of a less concentrated granular preparation was not ascertained.

An interesting observation made in 1964 was the control of velvet leaf (Abutilon theophrasti) with incorporated treatments, whether pre-plant or pre-emergence. Evidently, velvet leaf is capable of germinating from depths greater than those from which other annual weeds germinate. Incorporation obviously puts the herbicides in contact with the germinating velvet leaf thereby effecting control. Control was produced by trifluralin, EPTC and R-1607 (also with emergence applications, Table 5).

In Tables 4 and 5 are presented summaries on the performance of some promising pre-emergence herbicides evaluated in 1963 and 1964, respectively. Notwithstanding that these two seasons were rather dry years, the herbicides listed are those which performed best of some 35 different herbicides under the prevailing conditions. The herbicides which have consistently performed well

include linuron, trifluralin, diphenamid, DCPA, and the combination of NPA + CIPC.

Of particular interest was the performance of the combination NPA + CIPC. The spray combination of 2 lb/A of each herbicide was superior to the commercial granular preparation of 3 lb/A + 2 lb/A, respectively.

Reference is made to Table 4 where a number of new compounds are listed. Although the degree of weed control may not approach that necessary for commercial production, it is believed that the performance of some of these would be greater in years with more favorable rainfall distribution.

Summary

Many herbicides were evaluated for weed control in soybeans.

Pre-plant soil-incorporated applications of trifluralin, R-1607, and EPTC have considerable merit for weed control.

Spray treatments of the thiolcarbamates herbicides, R-1607 and EPTC, are superior to granular treatments of the same herbicides.

Soil-incorporated trifluralin, R-1607, and EPTC, applied as pre-plant or pre-emergence treatments, are effective for the control of velvet leaf.

Outstanding pre-emergence herbicides include trifluralin, diphenamid, DCPA, NPA + CIPC, the thiolcarbamates, as well as a number of new experimental compounds.

Table 1. The effects of several pre-plant soil-incorporated herbicidal treatments on weed control, injury, and yield of soybeans. 1963.

Variety - Clark
Planted - May 28
Treated - May 27
Rated - July 3[1]

Harvested - November 12-13
Location - Adelphia
Soil Type - Freehold Sandy Loam

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grass Stand[2]	Grass Vigor[3]	Crop Response Stand[2]	Crop Response Vigor[3]	Crop Yield, bu/A
n-Propyl di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
	4	8.3	4.2	8.7	4.5	0.8	0.7	29.1
	6	8.9	3.3	9.3	5.4	1.1	1.0	27.5
						10G		
	4	8.5	3.2	8.5	3.5	0.5	0.8	25.6
	6	8.9	4.2	8.9	3.8	1.9	2.2	25.0
Ethyl N,N-di-n=propythiolcarbamate (EPTC), 6 lb/gal								
	4	7.5	4.1	8.6	4.9	2.6	2.7	22.2
	6	7.7	3.6	8.7	4.4	2.8	2.3	18.6
						5G		
	4	6.9	4.2	8.5	6.6	3.3	3.1	18.9
	6	8.5	3.9	9.5	7.3	4.7	3.9	16.2
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin)								
						4 lb/gal		
	½	7.9	3.5	7.2	3.3	0.0	0.1	26.8
	1	7.0	3.6	7.8	3.7	1.1	0.6	26.3
	2	8.9	4.8	9.2	6.5	2.7	4.5	22.3
Check - Cultivated		0.0	0.2	0.0	0.2	0.0	0.0	26.1
Uncultivated		0.7	0.6	0.9	0.2	0.0	0.2	16.8
L.S.D.	0.05							5.2
	0.01							7.4

[1] Average of four replications and three ratings per replication.
[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 - mostly pigweed and lambsquarters; some crabgrass and carpetweed.

Table 2. The effects of several pre-emergence herbicidal treatments on weed control, injury, and yield of soybeans. 1963.

Variety - Clark
Planted - May 28
Treated - May 28
Rated - July 3[1]

Harvested - November 12-13
Location - Adelphia
Soil Type - Freehold Sandy Loam

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response: Stand[2]	Crop Response: Vigor[3]	Crop Yield, bu/A
n-Propyl-di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
	4 inc.	8.6	2.9	8.9	5.2	0.0	0.0	28.8
						10G		
	4 inc.	8.4	2.8	8.2	3.5	0.0	0.1	25.4
	4 uninc.	7.6	1.5	8.4	2.2	0.1	0.3	26.1
Ethyl N,N-di-n-propylthiolcarbamate (EPTC), 6 lb/gal								
	4 inc.	6.4	2.7	8.3	4.2	0.0	0.2	19.7
						5G		
	4 inc.	7.4	2.2	9.6	6.2	0.2	0.6	26.2
	4 uninc.	7.1	2.2	9.4	7.2	0.3	0.1	30.4
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), 4 lb/gal								
	3	8.2	2.9	8.9	5.7	0.2	0.1	27.7
	6	9.1	4.6	9.5	5.7	0.0	0.0	30.3
Check - Cultivated		1.9	1.1	1.6	0.7	0.0	0.1	25.8
L.S.D. 0.05								4.5

[1] Average of four replications and three ratings per replication.

[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 - mostly pigweed, lambsquarters, carpetweed, and crabgrass.

Table 3. The effects of a number of pre-plant soil-incorporated herbicidal treatments on weed control, injury, and yield of soybeans. 1964.

Variety - Clark
Planted - May 26
Treated - May 26
Rated - July 1[1]

Harvested - November 5
Location - Adelphia
Soil Type - Freehold Sandy Loam

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response: Stand[2]	Crop Response Vigor[3]	Crop Yield, bu/A
n-Propyl di-n-propylthiolcarbamate (R-1607), 6 lb/gal								
	4	7.1	1.5	6.2	1.2	1.8	2.1	44.8
	6	7.8	2.6	7.2	2.7	2.3	4.3	48.0
						5G		
	4	8.8	2.8	9.1	5.2	2.6	5.8	48.6
	6	8.7	4.4	8.5	6.4	3.3	6.9	62.1
a,a,a-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), 4 lb/gal								
	½	7.0	2.0	7.3	1.8	0.6	1.1	56.5
	1	8.2	3.8	8.1	3.0	0.6	1.0	48.3
	2	8.7	2.6	9.2	3.1	1.2	2.5	57.2
Check - Uncultivated		1.4	0.3	2.0	0.3	0.1	0.1	44.8

[1] Average of three replications and two ratings per replication.

[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 - velvet leaf, lambsquarters, pigweed, carpetweed, and crabgrass.

Table 4. Some pre-emergence herbicidal treatments that exhibited promise for weed control in soybeans. 1963.

Variety - Clark
Planted - May 28
Treated - May 28
Rated - July 3[1]

Harvested - November 12-13
Location - Adelphia
Soil Type - Freehold Sandy Loam

Treatment	Rate, lb/A	Weed Control: Broadleaves stand[2]	Broadleaves vigor[3]	Grasses stand[2]	Grasses vigor[3]	Crop Response stand[2]	Crop Response vigor[3]	Crop Yield, bu/A
N,N-dimethyl-2,2-diphenylacetamide (diphenamid), 80W								
	4	8.3	4.3	8.2	3.6	0.0	0.2	18.8
	6	9.4	5.8	3.7	4.9	0.0	0.0	20.4
Dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA), 75W								
	12	6.9	1.9	7.3	2.5	0.1	0.4	13.4
N-Cyclooctyl-dimethylurea (ALIPUR), 2 lb/gal								
	4	8.3	5.0	7.8	3.2	0.2	0.2	17.0
	6	8.8	4.0	8.5	3.8	0.0	0.2	15.1
3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea (linuron), 50W								
	1	6.9	4.1	3.4	2.0	0.0	0.5	10.4
	2	7.9	3.9	4.2	2.4	0.0	0.3	11.0
N-(p-Chlorophenyl)-0-N',N'-trimethylisourea (BAYER 40557), 6 lb/gal								
	6	8.5	3.9	6.9	2.6	0.3	0.5	12.0
	8	8.3	3.5	5.7	0.9	0.1	0.1	14.7
2,4-bis(Isopropylamino)-6-methylmercapto-s-triazine (prometryne), 80W								
	4	8.2	3.8	7.7	2.9	0.2	0.8	17.0
2,6-Dichlorobenzonitrile (dichlobenil), 50W								
	3	8.8	5.2	8.5	4.4	1.5	2.2	19.9
	4	9.4	5.8	9.6	5.5	0.5	0.7	17.6
N-1-Naphthylphthalamic acid (NPA) + isopropyl N-(3-chlorophenyl) carbamate (CIPC)								
	2 + 2 (L)	9.2	6.4	7.3	4.1	0.0	0.4	15.3
	3 + 2 (G)	8.0	4.6	7.7	3.4	0.8	1.8	13.8
NPA	2	9.2	6.3	8.4	4.3	0.8	0.7	15.9
	4	9.3	7.4	8.9	4.5	0.5	1.5	17.9
Check - Cultivated		1.3	1.3	1.1	0.7	0.0	0.3	11.0
L.S.D. 0.05								5.0

[1] Average of four replications and four ratings per replication.
[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, carpetweed, and crabgrass.

Table 5. Some pre-emergence herbicidal treatments that exhibited promise for weed control in soybeans. 1964.

Variety - Clark
Planted - May 19
Treated - May 21
Rated - July 1[1]

Harvested - November 5-7
Location - Adelphia
Soil Type - Freehold Sandy Loam

Treatment	Rate, lb/A	Weed Control: Broadleaves Stand[2]	Broadleaves Vigor[3]	Grasses Stand[2]	Grasses Vigor[3]	Crop Response Stand[2]	Crop Response Vigor[3]	Crop Yield, bu/A
Experiment 1 (Older herbicides)								
Linuron, 50W								
	1	6.9	0.7	7.2	2.5	0.8	0.6	38.0
	2	7.3	1.3	7.1	0.2	1.5	2.0	69.0
2,4-Dichlorophenyl-4-nitrophenyl ether (FW 925), 2 lb/gal								
	4	7.4	0.7	8.9	2.1	1.3	0.7	37.2
	6	7.1	1.3	6.3	2.5	1.1	1.0	62.8
DCPA, 75W								
	12	7.0	0.5	8.5	4.1	1.4	1.5	55.3
Trifluralin, 4 lb/gal								
	3	7.3	0.8	8.4	1.9	1.3	0.9	48.9
	5	7.7	0.6	8.6	2.2	1.0	1.1	62.8
R-1607, 5G (applied prior to emergence)								
	2 inc.	6.8	0.8	8.9	3.6	0.9	0.7	51.8
	4 inc.	7.3	1.2	8.2	1.0	1.3	1.3	52.0
Check-Cultivated		4.8	0.3	7.6	3.6	0.9	0.5	57.1
L.S.D.								N.S.
Experiment II (New experimental herbicides)								
N-4-(p-Chlorophenyoxy)-phenyl-N',N'-dimethylurea (TENORAN), 50W								
	6	6.3	0.7	6.9	1.5	1.2	1.3	74.1
N-Isopropyl-a-chloroacetamide (CP 31393), 65W								
	5	5.6	0.7	6.4	2.4	0.9	0.9	60.0
	6	6.6	0.8	6.8	2.8	0.4	0.8	61.0
Bayer 43975 (chemistry undisclosed), 75% E.C.								
	6	8.5	1.0	7.9	1.7	1.4	1.5	84.1
Bayer 55962 (chemistry undisclosed), 70% E.C.								
	4	6.4	6.6	7.8	1.7	0.7	0.8	50.1
Bayer 55967 (chemistry undisclosed), 25% E.C.								
	6	6.3	1.3	5.9	1.0	1.4	2.0	66.9
OCS-21944 (chemistry undisclosed), 1 lb/gal								
	6	6.8	0.4	7.2	2.0	1.0	0.3	66.1
CP-45592 (chemistry undisclosed), 4 lb/gal								
	2	6.9	0.9	8.3	2.6	1.7	1.6	50.5
	4	6.7	1.4	5.7	1.6	0.7	1.2	69.2
G-14260 (chemistry undisclosed), 50W								
	4	6.6	1.1	7.8	3.5	0.7	1.1	70.3
3,4-Dichlorobenzyl-N-methylcarbamate (UC-22463), 4 lb/gal								
	4	6.1	0.9	7.6	1.8	0.3	1.2	67.7
	8	8.5	2.9	6.1	4.2	2.3	2.6	92.8
Check-Cultivated		3.1	0.8	4.6	1.3	0.6	0.7	60.2
L.S.D. 0.05								6.0

1/

TOLERANCES OF SUGAR BEETS TO SEVERAL SYSTEMS OF DCPA

B. M. Metzger, R. D. Ilnicki and E. J. Visinski[1]

The selectivity of herbicides has been found to be dependent upon many variables, some of which may be readily controlled or altered. Recently, much attention has been given to those variables which involve the preparation of the herbicide itself. The variables are sometimes collectively referred to as formulations. For the purposes of this paper the term formulation will be employed in its more restricted sense, i.e. whether the compound is employed as an acid, base, or salt. The terms system and carrier will be used to further elucidate the loose term, formulation.

Extensive investigations have also been made of the effect of the age of the treated plant on the response to the herbicide treatment.

The purpose of the following experiment was to examine the effect of various systems of DCPA on sugar beets at various stages of growth.

Materials and Methods

Sugar beets were employed because of their sensitivity to dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA). Arasan-treated beet seeds were planted in a 1:1 sand to soil mixture in flats 8" x 12" and placed on greenhouse benches for the duration of the experiment. Table 1 lists the number of weeks after emergence that the treatments were made and the stage of growth of the beets on these dates. One flat was used for each treatment and a completely new set of flats was treated on each treatment day.

Table 1. Time of treatment and corresponding stages of beet growth.

Weeks after Emergence	Stage of Growth of Beets
1	2 leaves
2	3-5 leaves
3	6-8 leaves
4	10-14 leaves

[1]Research Fellow in the Department of Environmental Science, Research Specialist in Weed Control, and Field Technician, respectively, Rutgers - The State University, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey.

The systems and carriers and rates of this herbicide employed appear in Table 2. All materials were supplied by Diamond Alkali Company.

Table 2. Systems, carriers, and rates of DCPA used.

System	% AI	Carrier: Code No. and granular size	Carrier: Rate of Release	Rate, lb/A
Granular	5	PG-SB (20/35)	Slow	6 12
	5	SY-MB (30/60)	Moderate	6 12
	5	PG-FB (20/35)	Fast	6 12
W.P.	75	Commercial	--	6 8 10 12

Granular materials were applied with a hand shaker. Additional inert carrier was added to the active material in an effort to obtain even distribution over the surface area of the flats. The wettable powder was applied with a knapsack sprayer with deliveries made at the volume of 40 gpa. Following treatment all flats were watered.

Observations were taken periodically with the final ones being made 7 weeks after the last treatment date.

Results and Discussion

A summary of the observations made 11 weeks after the initial treatments and 7 weeks after the last treatments appears in Table 3. A verbal description of the observations follows.

Table 3. Relative tolerance exhibited by sugar beets at various stages of growth to DCPA*.

Treatment	Rate, lb/A	Weeks after emergence when treated			
		1**	2	3	4
W. P.	6	2	2	2	2
	12	1	1	1	1
Granular					
Slow release	6	5	6	4	5
	12	5	5	3	7
Moderate release	6	4	7	6	4
	12	3	4	7	3
Fast release	6	5	6	7	6
	12	5	3	5	8

* Rated on numerical scale with 1 being the least tolerant and each successively higher number indicating increased tolerance.

** Each treatment date rated independently.

Sugar beets treated 1 week after emergence exhibited little or no tolerance to the various treatments. The wettable powder system caused more severe injury than did the granular systems. The injury caused by all of the granular systems was sufficiently severe to mask any difference between rates.

Plants treated 2 weeks after emergence exhibited only a slightly increased tolerance over younger plants. The wettable powder system again caused more injury than did the granular. With the granular systems, the medium rate of release carrier accounted for the least injury to beets with the fast rate of release carrier causing less than the slow one. In all systems the degree of injury was directly proportional to rate.

Sugar beets treated 3 weeks after emergence exhibited a markedly increased tolerance to all treatments. The wettable powder system as in preceding periods of treatment caused the most severe response. The granular systems as in the previous stage exhibited the same order of toxicity.

Plants treated 4 weeks after emergence are only slightly more tolerant to DCPA than 3-week old plants. The wettable powder system as in all instances induced the greatest injury. The granular systems, however, have an increasing order of toxicity as follows: fast, slow, and moderate.

Summary and Conclusions

1. The tolerance of sugar beets to DCPA markedly increases between 2 and 3 weeks after emergence.

2. The wettable powder system caused more injury to sugar beet: than the granular systems at all stages of growth tested.

3. The granular systems of DCPA studied had the following orde

WEED CONTROL TRIALS IN SUGAR BEETS WITH PYRAZON

Richard D. Hart[1]

The selective herbicidal activity of pyrazon (1-phenyl-4-amino-5-chloro-pyridazone-6) for weed control in sugar beets was discovered by Fisher (1) in 1962 and this material has been extensively tested in sugar beet growing areas of the United States during the past three years. Registration of an experimental label for the use of pyrazon on sugar beets was granted by the USDA on April 1, 1964, and data has been collected and submitted for a full label.

The commercial production of sugar beets for sugar in the United States has been limited generally to areas close to sugar beet processing factories in approximately twenty-one Western and North Central states. Recent plans for construction of sugar beet processing factories and the probability of growing sugar beets in the Northeastern states makes a report on field tests with pyrazon and other materials at the Amchem Research Farm appropriate at this conference.

1962 TESTS

Procedure

Logarithmic pre-emergence applications of pyrazon as an 80% wettable powder were made in museum type screening plots on June 19, 1962. Treatments were replicated twice and the rates ranged from 8 lb/A to 1 lb/A. Rainfall of 1.72 in. was recorded on June 12, 1.07 in. June 13, 0.12 in. June 14, 0.22 in. June 20, 0.24 in. June 21, and 0.60 in. June 25. Virtually the only weed occurring in these plots was pigweed (*Amaranthus retroflexus*).

Results

Observations of reduction in plant stand and/or growth are presented in Table 1. Sugar beets were completely killed by 8 lb/A but they appeared normal at rates of approximately 6 to 7 lb/A.

Table 1 Average reduction in plant stands and/or growth from pre-emergence logarithmic applications of pyrazon 80W.

	Control July 20, 1962			
Test plant	8 lb/A	4 lb/A	2 lb/A	1 lb/A
Sugar beets	100%	0%	0%	0%
Soybeans	95	50	0	0
Sorghum	30	15	0	0
Alfalfa	100	80	25	0
Wheat	90	30	20	0
Carrots	100	45	15	0
Pigweed	100	90	75	35

[1] Agricultural Chemicals Division, Amchem Products, Inc., Ambler, Pennsylvania

1963 TESTS

Procedure

Sugar beets were planted on May 28, 1963, in plots 4.5 feet by 9 feet. Row spacing was 2½ feet so that each plot contained two 9-foot rows of beets.

Pre-emergence treatments replicated three times were applied on May 29. Rainfall of 0.37 in. was recorded on May 30th and 0.57 in. on June 4. Early post-emergence treatments replicated twice were applied on June 6, two days after first indication of beet emergence. Only a very few small weeds had emerged at that time. Late post-emergence treatments replicated twice were applied on June 26. Beets at the late post-emergence treatment date had 4 and 5 true leaves and were 5 to 6 inches high. Weeds, especially some pigweed plants, were also up 5 to 6 inches high. The principal weeds in the plot area were pigweed and foxtail (*Setaria faberii*).

Results

Pre-Emergence:

Visual estimates of weed control and sugar beet injury for the pre-emergence treatments are presented in Table 2. Pyrazon at 4.5 lb/A produced reasonably good control of the pigweed, but was weak on the foxtail. Eight pounds of TCA gave excellent grass control and quite good pigweed control, but also produced some beet injury.

Table 2 Average reduction in plant stands and/or growth from pre-emergence treatments.

Treatment		Control July 2, 1963		
Material	active/A	Broadleaf weeds	Grass weeds	Sugar beets
Pyrazon 80W	3 lb	82%	32%	0%
Pyrazon 80W	4.5	90	55	0
Pyrazon 80W	6	94	70	0
Pyrazon 80W	9	98	92	5
TCA	8	85	98	20
Endothal	6	33	17	0

Early Post-Emergence:

Observations of the early post-emergence treatments are presented in Table 3. It appeared that early post-emergence applications of pyrazon were slightly more effective than the pre-emergence applications.

Table 3 Average reduction in plant stands and/or growth from early post-emergence treatments.

Treatment		Control July 2, 1963		
Material	active/A	Broadleaf weeds	Grass weeds	Sugar beets
Pyrazon 80W	3 lb	88%	75%	0%
Pyrazon 80W	4.5	97	83	0
Pyrazon 80W	6	90	75	0
Dalapon	3	78	97	8
TCA	6	70	93	5
Endothal	1.5	80	83	88

Late Post-Emergence:

Observations of the late post-emergence treatments are presented in Table 4. No treatment appeared to cause more than slight injury to the beets but estimates of beet injury were not made since the heavy weed stand may have provided partial protection, thus making results misleading. The combination of pyrazon with dalapon at 3 + 4 lb/A produced the best weed control.

Table 4 Average reduction in plant stands and/or growth from late post-emergence treatments.

Treatment		Control August 7, 1963	
Material	active/A	Broadleaf weeds	Grass weeds
Pyrazon 80W	3 lb	20%	0%
Pyrazon 80W	4.5	40	5
Pyrazon 80W	6	63	0
Pyrazon 80W	9	83	15
Pyrazon 50W + Dalapon	3 + 4	60	90
Pyrazon 50W + TCA	3 + 6	50	78

1964 TESTS

Procedure

Plots 9 feet by 20 feet were laid out and pre-planting treatments were applied and incorporated on May 12, 1964. Incorporation was accomplished by rototilling once to a depth of approximately three inches with a 4-foot wide tractor-mounted rototiller. Incorporation was completed less than five minutes after the spray was applied. Sugar beets were immediately planted (27-inch row spacing) in the incorporated plots and for later pre-emergence and the post-emergence treatment. Pre-emergence treatments were applied on May 12, 1964, and post-emergence treatments were applied on May 28, 1964. At the time of post-emergence treatment sugar beets were under 2 in. tall, ragweed (Ambrosia artemisifolia) was under 1 in., lambsquarter (Chenopodium album) and pigweed (Amaranthus retroflexus) were under 3/4 in. and foxtail (Setaria faberii) was under 3 in. All treatments were replicated four times in the split plot design.

Rainfall of 0.95 in. was recorded on May 1, 0.66 in. on May 14, 0.05 in. on May 15, and 0.02 in. on May 20.

Results

Visual estimates of weed control and beet injury for this test are presented in Tables 5, 6 and 7. Ratings were possible on ragweed and sugar beets for all parts of the test. Ratings were also made on lambsquarters and foxtail in the incorporated part of the test and on lambsquarters, pigweed and foxtail in the post-emergence portion of the test.

The 50W formulation of pyrazon proved more effective than the 10% granular in both the incorporated and the pre-emergence treatments. The combination of Eptam with pyrazon incorporated appeared to be of value over pyrazon for the control of the foxtail. Pyrazon applied pre-emergence at 4 to 6 lb/A gave very good to excellent broadleaf weed control; it was not as effective post-emergence as incorporated or pre-emergence. Pyrazon 50W + dalapon at 4 + 3 lb/A was the most effective treatment for the post-emergence control of both broadleaf and grass weeds.

Table 5 Average reduction in plant stands and/or growth from incorporated treatments.

Treatment		Control June 17, 1964			
Material	active/A	Sugar beets	Ragweed	Lambsquarters	Foxtail
Pyrazon 50W + Eptam	2 + 1.5 lb	4%	94%	95%	98%
Tillam	4	1	53	53	95
Pyrazon 50W	4	0	97	94	80
Pyrazon 50W	6	1	99	100	88
Pyrazon 10G	4	5	86	74	67
Pyrazon 10G	6	1	95	94	82

Table 6 Average reduction in plant stands and/or growth from various pre-emergence treatments.

Treatment		Control June 17, 1964	
Material	active/A	Sugar beets	Ragweed
Pyrazon 50W	4 lb	0%	84%
Pyrazon 50W	6	5	93
Pyrazon 10G	4	0	53
Pyrazon 10G	6	5	68
Pyrazon 50W + TCA	3 + 5	0	70
TCA	6	1	3
Pyrazon 50W + CP-31392	3 + 4	0	91
CP-31392	6	0	56
Pyrazon 50W + TD-282	3 + 2	0	65
TD-282	4	0	43
Pyrazon 50W + CP-32179	3 + 2	3	68
CP-32179	3	0	8
Pyrazon 50W + CP-45592	3 + 1	0	79
CP-45592	1.5	3	40
Pyrazon 50W + Dupont 634	3 + 1	5	90
Dupont 634	1.5	0	65

Table 7 Average reduction in plant stands and/or growth from various post-emergence treatments.

Treatment		Control June 26, 1964				
Material	active/A	Sugar beets	Ragweed	Lambsquarters	Pigweed	Foxtail
Pyrazon 50W	4 lb	3%	76%	33%	61%	8%
Pyrazon 50W	6	0	95	66	92	34
Pyrazon 50W + Dupont 634	3 + 1	0	98	65	74	35
Dupont 634	1.5	0	70	40	18	15
Pyrazon 50W + TD-273	3 + 2	11	98	23	76	99
TD-273	3	53	98	0	98	82
Pyrazon 50W + Dalapon	4 + 3	10	95	95	80	98
Dalapon	4	21	35	25	33	75
Pyrazon 50W + CP-45592	3 + 1	23	94	97	99	53
CP-45592	1.5	3	54	48	54	20
Pyrazon 50W + CP-32179	3 + 2	10	86	92	98	13
CP-32179	3	3	30	34	40	13

DISCUSSION

Pre-emergence logarithmic applications of pyrazon in Pennsylvania in 1962 confirmed that sugar beets are more tolerant of pyrazon than are pigweed and several other crops. Treatments in 1963 indicated that, although both pigweed and foxtail could be controlled selectively in sugar beets, the foxtail required considerably higher rates. Combinations of pyrazon with herbicides more active on grasses were initiated in 1964, but satisfactory evaluations were not possible because the stand of grasses was too sparse and varied.

Pre-emergence treatments were compared with pre-plant incorporated treatments in 1964. The latter appeared somewhat more effective. A 10% active granular formulation of pyrazon on 15/30 attaclay was compared with a wettable powder spray. In both the incorporated and the pre-emergence plots the granular material was less active. The low solubility of pyrazon may account for this poorer performance; a satisfactory granular might be obtained by using a smaller particle, a less concentrated formulation or a different carrier.

Post-emergence treatments were applied at two stages of growth in 1963. Rates of 3 lb/A in the treatments applied only two days after the beets emerged produced better results than 9 lb/A applied when the beets and weeds were 5 to 6 inches tall. Pyrazon tended to be weaker on grasses than broadleaf weeds in these post-emergence treatments, as in the pre-emergence tests. Combination of pyrazon with TCA and with dalapon in late post-emergence treatments gave considerably better control of the grass than did pyrazon alone and in this case also increased control of the broadleaf weeds. Applications of pyrazon in 1964 at a stage of growth intermediate to the two in 1963 produced an intermediate degree of weed control. A number of combinations were applied in 1964; pyrazon at 4 lb/A plus dalapon at 3 lb/A was the most satisfactory treatment.

CONCLUSIONS

In Pennsylvania pre-plant incorporated, pre-emergence and early post-emergence treatments of pyrazon at 4 to 6 lb/A produced very good to excellent selective weed control in sugar beets. The post-emergence effectiveness of pyrazon decreases progressively as application is delayed after weeds have emerged. Pyrazon tends to be somewhat weak on grass weeds and mixtures with herbicides which are more active on grasses can produce better over-all control where both broadleaf weeds and grasses occur.

REFERENCE

1. Fisher, A. 1962. Weed Research 2:177-184.

CONTROL OF ANNUAL GRASSES AND BROADLEAF WEEDS IN SUGAR BEETS.

M.F. Trevett and William Gardner[1/]

INTRODUCTION

This paper is a report of pre-emergence and post-emergence tests made in sugar beets in 1964 with the herbicides listed in Table 1.

Procedure

At Monmouth, Maine, a Great Western variety of sugar beets was planted three quarters of an inch deep in a loam soil in rows thirty-six inches apart.

Treatments were applied with a single pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. Each treated plot was adjacent to a check plot.

Plantings were made three to four weeks later than normal commercial plantings. Yields, therefore, are lower than ordinarily would be expected.

Beets were harvested the 12th to 17th of October.

In the statistical analysis of weed control, the arcsine transformation for percent was used. Because of space limitations only the reconverted means are given.

Broadleaf weeds included: Red-root pigweed (*Amaranthus Retroflexus* L.); Lambsquarters pigweed (*Chenopodium album* L.); Wild rutabaga (*Brassica rapa* L.). Barnyard grass (*Echinochloa crusgailli* (L.) Beauv.) was the principal annual grass.

1. Herbicides applied at-planting, Block I, Table 3.

The herbicides in this test were applied to powder-dry soil 9 June. A significant amount of rain had not fallen since the 16th of May, Table 2.

Under these conditions only pyrazon, or combinations of pyrazon with other herbicides gave acceptable annual grass or annual broadleaf weed control. Pyrazon alone was as satisfactory as pyrazon-dalapon or pyrazon-tupersan combinations. Compare/2 and 4, 2 and 9, 2 and 13, Table 3.
treatments

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Four pounds of pyrazon per acre gave as good control of both broadleaf weeds and annual grasses as six pounds. Compare treatments 2 and 5, 4 and 7, Table 3. Pyrazon applied at planting appeared to control Lambsquarter pigweed and Wild Rutabaga better than Redroot Pigweed.

In Block 3 a tendency for tenoran and UC-22463 emulsifiable to reduce beet stand is evident, Table 3. This block was abandoned before harvest because of a heavy infestation of Quackgrass.

2. Herbicides applied at emergence and post-emergence, Block II, Table 4.

Block II was heavily infested with quackgrass.

Soil moisture was more favorable when the emergence treatments of Block II were applied 15 June than when the at-planting treatments of Block I (10 June) were applied. Forty-one-hundredths of an inch of rain fell June 15, Table 2. This resulted in increased control for some herbicides that were unsatisfactory "at planting". For example, 6 pounds per acre of tupersan at planting gave 39.8 percent control of annual grass, at emergence 87.1. However, only one treatment (Treatment 2, Table 4) gave yields that were not significantly lower than hand hoed plots. The high yield in the pyrazon-tupersan-dalapon combination resulted not from enhanced annual grass or annual broadleaf control but from the near elimination of quackgrass.

All treatments with tenoran, whether alone or in combination with other herbicides, were unsatisfactory. Two, four, or six pounds of tenoran per acre significantly reduced beet stand. Thus, data for tenoran combinations are not included in Table 4.

3. Pyrazon-tupersan combinations applied pre-emergence, Block III, Table 5.

Quackgrass and annual grasses were not present in significant amount in Block III.

Through inadvertance neither pyrazon alone or tupersan alone was included in Block III. The combinations were applied because it was assumed that: 1/ tupersan is essentially a graminicide, 2/ pyrazon is more effective on annual broadleaf weeds than on annual grasses. So, to adequately control both classes of weeds, some combination of the two herbicides should be needed.

Under the soil and rainfall conditions of this test, and using yield of roots as a criterion, sugar beets were tolerant of combinations of pyrazon and tupersan up to and including acre rates of six pounds of each, treatment 6, Table 5. Four pounds of each gave broadleaf control statistically identical with higher rates, treatment 3, Table 5.

Data for UC-22463 are not included in Table 5. Four or six pounds did not control Wild Rutabaga and killed all beet seedlings.

4. Pyrazon-dalapon combinations applied post-emergence, Block IV, Table 6.

In Block IV, weeds were hand hoed and pulled in all plots before post-emergence treatments were applied.

This test was made to evaluate the tolerance of sugar beets to post-emergence applications of combinations of pyrazon and dalapon. At the time treatments were applied beets were 6 inches tall with 4 to 5 true leaves.

Hand hoeing , 1 or 2 pounds per acre of dalapon, and 4 pounds of pyrazon (treatments 1, 2, 8, and 3, Table 6), gave significantly higher yields than all other treatments except 1 pound dalapon plus 4 pounds pyrazon (treatment 6). One pound dalapon plus 2 pounds of pyrazon (treatment 4) did not differ significantly from treatment 6 in yield.

Dalapon applied at rates higher than 2 pounds per acre, whether applied alone or with pyrazon, reduced yields compared to hand hoed plots.

With a few exceptions, yields were related to the vigor ratings made 9 September: high rating, high yield; low rating, low yield.

SUMMARY

Four and 6 pounds of pyrazon applied at planting in sugar beets gave satisfactory control of annual grass and annual broadleaf weeds, although control of Red-root pigweed (*Amaranthus retroflexus* L.) appeared to be less certain than for Lambsquarters (*Chenopodium album* L.), and Wild Rutabaga (*Brassica rapa* L.).

A combination of 4 pounds pyrazon, 4 pounds tupersan, and 4 pounds dalapon applied when five percent of the sugar beets had emerged gave satisfactory control of annual grasses, annual broadleaf weeds, and quackgrass (*Agropyron repens* L. Beauv.). Yield of roots did not differ significantly at the 5 percent level from hand hoed plots.

Post-emergence application, when sugar beets were six inches tall, of 1 or 2 pounds per acre of dalapon, or 4 pounds of pyrazon, or 1 pound of dalapon plus 4 pounds of pyrazon, did not reduce yield compared to hand hoed check plots.

In pre-emergence application, sugar beets were tolerant of combinations of pyrazon and tupersan up to and including six pounds per acre of each herbicide.

Table 1. Herbicides Used in Sugar Beet Tests.

Designation	Active Ingredient
DALAPON	2,2-dichloropropionic acid
ENDOTHAL	7-oxabicyclo-(2.2.1) heptane-2,3-dicarboxylic acid
PYRAZON	5-amino-4-chloro-2-phenyl-3(2H)-pyridazinone
R-4461	N-(beta-O,O-diisopropyldithiophosphorylethyl benzene sulfonamide
TCA	Trichloroacetic Acid
TENORAN C-1983	N-4(P-chlorophenoxy)-phenyl-N',N'-dimethylurea
TUPERSAN	1-(2-methylcyclohexyl)-3-phenylurea
UC-22463	3,4-dichlorobenzyl-n-methyl carbamate

Table 2. Rainfall, Highmoor Farm, Monmouth, Maine, 1964.

Date	Inches	Date	Inches
May 8	.05	July 7	1.05
9	.12	8	.18
11	.02	13	.40
13	.15	14	.28
14	.34	18	.12
16	.31	21	.22
19	.17	22	.43
20	.07	23	.10
June 3	.14	Aug. 1	.04
4	.04	2	.22
7	.02	8	.06
15	.41	11	.04
20	.04	12	1.00
24	.13	13	.07
26	.40	15	.10
29	.45	17	.23
31	.19	18	.04
July 1	.10	22	1.75
2	.09	23	.67
3	1.74	24	.26
4	.18	Sept. 1	.21
6	.34	4	.24
		9	.10

Table 3. Block I: Herbicides[1] Applied at Planting.

Treatment number and acre rate of active ingredient	Stand of beets per 5' of row before thinning	Percent: Annual grass control 17 August '64	Percent: Broadleaf control 17 August '64
2. 4# Pyrazon	22.5a[2]	75.0abcde[2]	72.5 b[2]
3. 6# Tupersan	18.7ab	39.8 cdefg	11.5 efg
4. 4# Pyrazon + 2.2# Dalapon	17.5abc	77.5abcd	78.7ab
5. 6# Pyrazon	16.7abcd	88.8ab	81.2ab
6. 2# Tupersan	16.6abcd	11.8 fgh	15.2 defg
7. 6# Pyrazon + 2.2# Dalapon	15.2abcde	85.0ab	76.2ab
8. R-4461	14.5abcdef	1.0 h	11.5 fg
1. Hand hoed	11.7abcdefg	99.8a	100.0a
9. 4# Pyrazon + 4# Tupersan	12.7abcdefg	48.0 bcdef	71.7 bc
11. 2# Tenoran	8.2 cdefgh	1.0 h	50.0 bcde
12. 4# Tupersan + 4.4# Dalapon	7.2 defgh	30.5 fgh	11.2 efg
13. 4# Pyrazon + 4.4# Dalapon	7.2 defgh	80.0abc	54.0 bcd
14. 4# Tupersan	6.7 efgh	18.0 fgh	15.2 defg
15. 4# Tenoran	6.0 efgh	1.0 h	22.5 defg
16. 6# UC-22463-EM[3]	6.0 efghi	10.8 fgh	15.2 defg
17. 15# R-4461 + 4# UC-22463-EM	5.7 fghi	26.8 fgh	23.2 defg
18. 4" UC-22463-EM	5.0 ghi	11.0 fgh	27.5 cdefg
19. 8# UC-22463-EM	4.2 ghi	19.5 fgh	15.1 defg
20. 4# Tupersan + 6# UC-22463-EM	4.0 ghi	48.2 bcdef	30.7 cdefg
21. 2# Tenoran + 2.2# Dalapon	5.0 ghi	3.2 gh	15.2 defg
22. 2# Tenoran + 4.4# Dalapon	3.2 hi	21.8 fgh	6.7 fg
23. 4# Tenoran + 6# UC-22463	3.0 hi	9.5 fgh	34.5 cdefg
24. 4# Tupersan + 5# Tenoran	2.0 i	31.5 efgh	2.2 g
25. 4# Tenoran + 4.4# Dalapon	0.7 i	35.2 defgh	40.2 bcdef

1/ Planted 9 June '64; herbicides applied 10 June '64. Soil: powder dry at time herbicides were applied. Block was abandoned because of heavy infestation of quackgrass (*Agropyron Repens* L.).
2/ Duncan's Multiple Range Test, 5% level: Means with the same letters are not significantly different.
3/ EM = emulsifiable.

Table 4. Block II:[1] Herbicides Applied at Emergence and Post-Emergence.

Treatment number, acre rate of active ingredient and time of application	Beet Vigor[3] Means: Percent	Stand of beets per 25' of row	Weed Control: 10 September '64 Annual grass	Weed Control: 10 September '64 Broadleaf	Yield: lbs. root per 25' of row
1. Hand hoed	98.0a[4]	24.0[4]	100.0a[4]	100.0a[4]	40.7a[4]
2. (4# Pyrazon + 4# Tupersan + 4# Dalapon)-EM[2]	77.5 b	39.7a	91.3a	77.2ab	33.4a
3. (6# Tupersan)-EM	51.2 b	37.5a	87.1a	1.0 d	15.6 b
4. (4# Tupersan)-EM	47.2 b	38.5a	67.2a	1.0 d	11.2 b
L.S.D. 5%					6.8

Table 5. Block III: Pre-Emergence Application of Tupersan Plus Pyrazon.[5]

Treatment number, acre rate of active ingredient, and time of application	Beet Vigor[3]	Number beet plants per 25' of row after thinning	Percent: broadleaf weed control	Yield: lbs. roots per 25' of row
1. Hand hoed	83.8[4]	35.0abc[4]	100.0a[4]	37.6a[4]
2. (4# Tupersan + 6# Pyrazon) PRE[2]	73.8ab	28.2 c	95.0ab	36.9a
3. (4# Tupersan + 4# Pyrazon) PRE	73.8ab	35.3abc	90.1 b	37.4a
4. (6# Tupersan + 4# Pyrazon) PRE	73.1ab	35.1abc	67.0 c	34.4a
5. (4# Tupersan + 3# Pyrazon) PRE	73.1ab	40.5a	57.5 c	34.0a
6. (6# Tupersan + 6# Pyrazon) PRE	72.9ab	29.1 bc	95.0ab	33.6a
7. (2# Tupersan + 4# Pyrazon) PRE	70.0a	41.7a	68.1 c	37.6a
8. (6# Tupersan + 3# Pyrazon) PRE	64.4 b	38.0ab	61.8 c	35.7a
9. (2# Tupersan + 3# Pyrazon) PRE	61.2 b	39.6a	50.0 c	32.8a

1/ Planted 9 June '64. Area heavily infested with quackgrass (Agropyron Repens L. Beauv.)
2/ EM = applied at emergence 16 June, 5% of the beets had emerged. The soil was moist from .41 inches of rain the preceeding day, Table 2.
PRE = applied pre-emergence, 22 June '64.
3/ 100 = high vigor, 1 = low vigor
4/ Duncan's Multiple Range Test. Means having same letters do not differ significantly at the 5% level.
5/ Planted 17 June '64.

Table 6. Block IV:[1] Dalapon Plus Pyrazon Applied Post-Emergence.

Treatment number and acre rate of active ingredient	Beet vigor 9 Sept. '64	Stand: Number of beet plants per 25' of row	Yield: lbs. roots per 25' of row
1. Hand hoed throughout season	88.5a[2]	28.0ab[2]	39.2a
2. 1# Dalapon	79.2ab	35.7ab	38.2a
3. 2# Dalapon	78.2ab	34.7ab	36.4 bc
4. 1# Dalapon + 2# Pyrazon	72.2 bc	30.5ab	33.0 de
5. 4# Dalapon + 2# Pyrazon	72.1 bc	32.5ab	23.5 i
6. 1# Dalapon + 4# Pyrazon	72.0 bc	37.2a	34.7 cd
7. 2# Dalapon + 2# Pyrazon	71.2 bc	31.0ab	26.5 h
8. 4# Pyrazon	68.5 bc	27.2ab	36.5abc
9. 4# Dalapon	68.0 bc	25.2 b	26.6 gh
10. 3# Dalapon	68.0 bc	32.2ab	30.8 ef
11. 2# Dalapon + 4# Pyrazon	66.5 bc	35.2ab	27.0 gh
12. 3# Dalapon + 4# Pyrazon	63.8 bcd	30.0ab	29.2 fg
13. 4# Dalapon + 4# Pyrazon	57.0 cd	31.5ab	21.5 i
14. 3# Dalapon + 2# Pyrazon	47.5 d	26.0ab	20.4 j

1/ Planted 17 June; hand hoed and weeded 13 June '64. Herbicides applied 16 July '64.

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

1964 WEED CONTROL TRIALS IN SUGAR BEETS

Stanford N. Fertig and Robert L. Zimdahl [1]

The rapid progress toward commercial sugar beet production in New York State and the well known fact that weed control would be a major problem, mandated a comprehensive herbicide evaluation during the 1964 growing season. Incorporated, preemergence and postemergence treatments were evaluated in randomized block replicated trials. Pre-and postemergence treatments were also investigated in logarithmic trials. All of the trials were carried out on the Cornell University Agronomy Department farm, Aurora, New York.

Experimental Methods and Procedure

The soil in the research area was predominantly Lima silty clay loam. In 1963 oats and a legume seeding were grown on this field and the new seeding was plowed in April 1964. This procedure, although not recommended, was necessary to avoid the possibility of Atrazine residue on fields which were in corn in 1963.

All plots were planted with an International Harvester model 185 four row mounted planter. The variety used was SL-126-MS x SP-5460-0. The uniform rate of fertilization was 800# of 10-20-20 per acre plus 1/4 percent Boron. Mustard (*Brassica* spp.) and yellow foxtail (*Setaria glauca* L.Beauv.) were broadcast on all plots at about 10 pounds per acre. Approximately 2 pounds per acre of a mixture of lambsquarters (*Chenopodium album* L.) and rough pigweed (*Amaranthus retroflexus* L.) was also seeded but germination was poor. Many weeds developed naturally, most important among these were:

Ground Cherry	(*Physalis* spp.)
Nutsedge	(*Cyperus esculentus* L.)
Flower-of-an-Hour	(*Hibiscus trionum* L.)
Smartweed	(*Polygonum* spp.)
Ragweed	(*Ambrosia artemisiifolia* L.)

Initially three trials were established:

1. An evaluation of the effectiveness of promising herbicides in a randomized block with four replications.
2. An evaluation of the interaction of cultivation and certain promising herbicides in a randomized block with four replications.
3. An initial evaluation of new herbicides in a randomized block with two replications.

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1. Professor and Graduate Assistant respectively, Department of Agronomy, Cornell University, Ithaca, New York.

The first two of these trials were planted on April 25, and the latter on May 7. Soil tests taken at that time indicated:

pH - 6.8
P - 10
K - 100
OM - 3.6
Boron - 1.4

All plots except the logarithmic plots, were four 28 inch rows wide and 20 feet long. Treatments were applied overall with either a specially adapted Allis Chalmers G tractor or a CO_2 hand sprayer. Incorporated treatments were double disked immediately after application. Treatments were applied in 30 gallons of water per acre. Herbicide combinations which went on at the same time were applied as a mixture.

As more information became available, it was evident that all potentially useful treatments had not been included in the above plots. Therefore, on June 1, additional beets were planted and used for logarithmic evaluation of new herbicides or combinations of herbicides. These plots were three 28 inch rows wide and 60 feet long. Treatments were applied both pre-and postemergence in 43 gallons of water per acre. A CO_2 hand logarithmic sprayer was used which had a half dosage concentration distance of 15 feet, resulting in four half dosage concentrations.

Seasons rainfall records were kept by the weather station on the Aurora farm and are summarized below. Rainfall for the period May 1 to July 31 was 50 to 70 percent of normal and for the period August 1 to September 30 was only 40 to 50 percent of normal.

Month	Total Rainfall	Month	Total Rainfall
April 1-15	1.32	July 16-31	0.29
April 16-30	2.52	Aug. 1-15	0.21
May 1-15	1.27	Aug. 16-31	2.09
May 16-31	0.80	Sept. 1-15	0.21
June 1-15	1.91	Sept. 16-30	0.31
June 16-30	0.42	Oct. 1-15	0.25
July 1-15	0.91	Oct. 16-31	0.81

SEASON TOTAL 13.32
AVERAGE 1961-63 ..... 19.55

Thinning was done by hand on all but the cultivated block. Two stand counts were made, one after thinning and one before harvest. Two weed counts were made at approximately the same time. Stand counts were made by counting all of the beets in the two center rows of each plot. Three two-square foot quadrats were employed for the weed count, one over each of the two center rows while the third was between these two rows, (6 square feet counted). In the cultivated block, 1-1/2 square foot quadrats were used over the rows and a two

Harvesting was accomplished with a sugar beet lifter adapted to an IH-404 tractor. Beets were topped by hand and weighed in the field where a sample for tare and sugar analysis was taken. The two center rows of each plot were harvested. Logarithmic plots were not harvested.

Results and Discussion

The seasons observations and yields for the promising herbicides are given in table 4.

The most promising herbicide for control of broadleaved species in the 1963 trials was Pyramin. Dalapon and TCA in combination with Pyramin (treatments 2-10 table 4) were investigated in 1964 in hopes of combining annual grass control with Pyramin. A brief description of results follows:

Table 1

A brief description of results with Pyramin and TCA, Pyramin and Dalapon combinations

Herbicide	Rate	Yield
Pyramin + TCA	2.0 + 6.8	6.66
Pyramin + TCA	4.0 + 6.8	8.95
Pyramin + TCA	6.0 + 6.8	9.88
Pyramin + Dalapon	2.0 + 4.0	2.49
Pyramin + Dalapon	4.0 + 2.0	9.76
Pyramin + Dalapon	4.0 + 3.0	8.27
Pyramin + Dalapon	4.0 + 4.0	9.07

Although both combinations gave excellent control they were not superior to TCA and Endothal at 6.8 and 4.1 pounds per acre which yielded 10.46 tons of beets per acre. The above yields also illustrate the definite increase in effectiveness of Pyramin with increasing rates of application.

Dupont 634 when incorporated resulted in 50 to 80 percent injury to the stand. However, at 3.0 pounds preemergence the yield was 7.60 tons of beets with an injury rating of 10 percent. Further evaluation of these and other combinations is needed before definite recommendations can be made.

Incorporated, pre-and postemergence applications of Pyramin were compared. There was no advantage, in terms of weed control, with incorporated or postemergence applications and there was a loss in yield from them.

Table 2

A Comparison of Pre-and Postemergence Applications of Pyramin. 1964

Herbicide	Rate	Time of Application	Yield
Pyramin	3.0	Inc.	4.20
Pyramin	3.0	Pre.	8.18
Pyramin + Dalapon	4.0 + 3.0	Early post	7.42
Pyramin + Dalapon	4.0 + 3.0	Late post	8.52
Pyramin + Dalapon	4.0 + 3.0	Pre	9.62

Although the results are not reported in this paper the more promising treatments from the logarithmic trials were Pyramin combinations: Pyramin + CP-45592, Pyramin + TD-273, Pyramin + CP-31393, Pyramin + TCA, and Pyramin + Dalapon. These combinations were quite effective for the control of both broadleaved weeds and annual grasses. No advantage was gained from early or late postemergence applications of these same treatments.

The following chemicals either killed the stand of beets completely or reduced it below an economic level.

RC-3056	TH-052-H
RC-3056 + TCA	GS-11349
Dupont 634 @ 3 and 6 pounds incorporated	GS-11357
	GS-11851
OCS-21944	GS-35123

The following chemicals were not effective for weed control in sugar beets under the conditions experienced in 1964.

SD-9796	Tillam
SD-9813	Treflan
SD-9515	Tupersan
ACA-105	

The third major trial was conducted to determine the interaction between cultivation and herbicidal weed control. In a dry year such as 1964, cultivation had a generally favorable effect on weed control achieved by herbicides. Table 3 is a comparison of selected treatments with and without cultivation.

Table 3

A comparison of selected herbicide treatments with and without cultivation - Sugar Beets - 1964

	Treatment	Rate/A # A.I.	Yield in tons/A Number of Cultivations			
			None	1	2	3
1.	Pyramin + TCA	2.0 + 6.8	6.66	8.89	9.82	10.42
2.	Pyramin + TCA	4.0 + 6.8	8.95	9.77	9.70	10.31
3.	Pyramin + Dalapon	4.0 + 3.0	9.62	9.27	8.67	10.26
4.	TCA + Endothal	4.6 + 2.7	2.64	7.25	9.00	7.35
5.	RC-3056	3.5	2.81	4.24	4.28	4.98

As indicated by this data, the effects of cultivation with a good herbicide treatment (2 or 3) were not as marked as with a poor herbicide (4 or 5). The benefit of more than one cultivation cannot be safely inferred from this data. The significance of cultivation to the farmer and the researcher should not be overlooked.

Pyramin gives consistent, (seasonal) control of most broadleaved species present in New York State with no injury to the beet stand. Pyramin has not given broadleaved control superior to that obtained with TCA plus Endothal. In terms of those herbicides approved for usage as of this date, TCA plus Endothal at the recommended rate of 6.8 plus 4.1 pounds is still the preferred treatment. Based on research evidence to date, if the broadleaved weed control given by Pyramin can be combined with good control of annual grasses, the combination would be superior to TCA plus Endothal in New York State. To balance effectiveness with cost these trials indicate no less than 3 pounds per acre of Pyramin should be used in such a combination.

Summary

Although many treatments have resulted in effective weed control in the research trials, there is at present no better treatment than TCA plus Endothal that can be recommended to growers.

Pyramin in combination with an effective grass control compound has been more effective than TCA plus Endothal under New York conditions.

Preemergence applications have been consistently superior when compared with either incorporated or postemergence applications.

Table 4

An Evaluation of the Effectiveness of Promising Herbicides for Sugar Beets
Treatments, Seasons Observations and Yields
1964

Treat No.	Herbicide	Rate/A # A.I.	Time of Appl. Inc.	Pre.	Post
1	TCA + Endothal	4.6 + 2.7		X	
2	TCA + Pyramin	6.8 + 2.0		X	
3	TCA + Pyramin	6.8 + 4.0		X	
4	TCA + Pyramin	6.8 + 6.0		X	
5	Pyramin +	2.0 +		X	
	Dalapon	4.0			X
6	Pyramin +	4.0 +		X	
	Dalapon	2.0			X
7	Pyramin +	4.0 +		X	
	Dalapon	3.0			X
8	Pyramin +	4.0 +		X	
	Dalapon	4.0			X
9	Pyramin + Dalapon	4.0 + 3.0		X	
10	Pyramin + Dalapon	4.0 + 3.0			X
11	RC-3056	3.5		X	
12	RC-3056	4.5		X	
13	RC-3056	5.5		X	
14	TD-273 + Dalapon	1.0 + 2.0			X
15	Endothal + Dalapon	1.0 + 2.0			X
16	TD-273	2.0			X
17	Endothal	2.0			X
18	Tillam	6.0	X		
19	RC-3056 + TCA	4.5 + 6.8		X	
20	Tillam +	4.0	X		
	Pyramin	2.0		X	
21	DuPont 634	3.0	X		
22	DuPont 634	6.0	X		
23	DuPont 634	3.0		X	
24	DuPont 634 +	3.0	X		
	Pyramin	3.0		X	
25	CP-31393 + Pyramin	3.0 + 3.0		X	
26	CP-31393 + Pyramin	3.0 + 2.0		X	
27	OCS-21693 + Pyramin	3.0 + 3.0		X	
28	OCS-21944 + Pyramin	3.0 + 3.0		X	
29	Pyramin	3.0	X		
30	Cultivated Check				

Table 4 (Con't)

An Evaluation of the Effectiveness of Promising
Herbicides for Sugar Beets
Treatments, Seasons Observations and Yields
1964

Treat. No.	Stand Counts* 6/10	Stand Counts* 9/4	Weed Counts** July 8 BL	Weed Counts** July 8 G	Weed Counts** Sept.16 BL	Weed Counts** Sept.16 G	Control*** Ratings BL	Control*** Ratings G	Injury**** Rating	Avg. Yield	Notes
1	37	31	13	23	47	12	1	1	0	3.54	
2	35	33	6	6	11	3	6	8	0	6.66	
3	36	35	3	2	5	1	8	8	0	8.95	
4	35	32	1	3	6	1	8	8	0	9.88	
5	31	29	13	1	5	1	2	8	0	2.49	
6	32	32	5	12	32	8	7	7	0	9.76	
7	36	37	2	1	5	1	8	9	0	8.27	
8	34	32	3	5	21	5	7	8	0	9.07	
9	34	32	4	14	28	7	7	5	0	9.62	
10	33	31	2	2	10	2	5	8	0	7.42	
11	16	16	6	23	67	17	5	1	2	2.81	
12	14	13	6	26	96	24	4	1	4	1.32	
13	6	6	4	22	85	21	6	1	8	1.41	
14	36	32	14	7	13	3	1	7	0	3.12	Early
15	35	32	18	2	10	2	1	7	0	2.59	Early
16	35	32	12	19	45	11	2	4	0	4.11	Early
17	36	35	12	25	62	13	3	1	0	5.14	Early
18	31	28	11	12	34	8	2	3	0	4.15	
19	6	7	5	9	26	6	4	7	8	1.63	
20	32	32	7	13	40	10	6	5	0	7.02	
21	11	11	1	13	41	10	7	3	5	4.36	
22	4	5	1	4	21	5	8	6	8	3.02	
23	25	29	2	3	34	8	7	7	1	7.60	
24	8	9	4	1	20	5	9	7	7	4.70	
25	31	31	4	1	19	5	8	5	0	7.48	
26	26	25	12	3	51	13	6	3	0	6.44	
27	30	29	36	9	16	4	3	6	1	3.96	
28	20	4	26	6	23	6	1	4	9	.30	
29	25	34	25	6	74	13	5	2	0	4.20	
30	33	32	33	8	29	7				2.34	

* In 40 feet of row

** In 3-2 sq. ft. quadrats/plot - Avg. 4 reps.shown

*** 0 - No control
10 - Complete control

**** [illegible]

IOXYNIL INDUCED RESPONSES IN SMALL GRAINS

Barbara M. Metzger, Richard D. Ilnicki, and John F. Ellis[1]

In the past few years several new experimental compounds have been introduced as promising post-emergence herbicides for the control of hard-to-kill broadleaf weeds in cereals. Ioxynil (3,5-diiodo-4-hydroxylbenzonitrile) falls into this category. In New Jersey several weeds appear in cereals which may be classified as hard-to-kill broadleaves. Of major concern is corn chamomile, Anthemis arvensis L., because of its incidence rate and tolerance to 2,4-D and its analogs.

Previous investigations (1,2) have shown that ioxynil produces good results at rates of 1/4 to 1/2 lb/A when applied to actively growing weeds in early stages of growth while higher rates are necessary for the control of older plants. These investigations also indicated that fall- and spring-seeded small grains were tolerant to ioxynil treatments of up to 4 lb/A with only temporary injury symptoms appearing which were not reflected in yield.

Materials and Methods

In the two seasons, 1962-1963 and 1963-1964, that these experiments were conducted, both Wong barley and Pennoll wheat were employed as test cereals. In 1963-1964 Clintland oats were also used. Barley and wheat were fall-seeded; oats were spring-seeded. With the exception of oats, all cereals stands were maintained weed free. All crops were treated at two of the following three stages of growth: tillering, fully tillered, and late joint-early boot. In Table 1 the stages of growth at time of treatment in either season are listed.

The herbicide ioxynil was used as four different formulations:

a. ACP-62-70A - 1.5 lb/gal emulsifiable oil soluble amine
b. ACP-62-70B - 2.0 lb/gal emulsifiable oil soluble amine
c. ACP-62-177 - 50% wettable powder, hammer milled
d. ACP-63-303 - 2.0 lb/gal lithium salt.

In Table 1 the crops and the season treated with these formulations are listed.

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The rates used varied with the formulation as follows:

a. ACP-62-70A - 1 lb/A
b. ACP-62-70B - 1/2, 1, 2 lb/A
c. ACP-62-177 - 1/2, 1, 2 lb/A
d. ACP-63-303 - 1/4, 1/2, 1, 2, 4 lb/A

All treatments were applied in water dilutions of 40 gpa.

Table 1. Summary of the spraying schedule and formulations of ioxynil used to treat wheat, barley, and oats.

	Stage of Growth			Ioxynil Formulation			
Crop	Tillering	Fully Tillered	Late joint-Early boot	ACP-62-70A	ACP-62-70B	ACP-62-177	ACP-63-303
Wheat							
1962-1963	X	X		X	X	X	
1963-1964		X	X				X
Barley							
1962-1963	X	X		X	X	X	
1963-1964		X	X				X
Oats							
1964	X		X				X

Just prior to harvest field observations were made on average heights of the cereals and numbers of tillers per 2 feet of row on a plot basis. In the single oat experiment, weed control of broadleaves and grasses and crop response were rated. These ratings were based on the scale of 0 to 10; 0 = no control or no effect, 10 = complete control or dead plant.

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

Results and Discussion

In Tables 2 and 3 data on the effects of ioxynil on numbers of tillers and yield of wheat and barley, respectively, are pre-

in Table 4. A summary of the weed control ratings in the single oat experiment conducted is presented in Table 5.

Table 2. Responses of Pennoll wheat to ioxynil formulations applied at tillering and fully tillered stages of growth (1962-1963)*

Formulation	Rate, lb/A	Tillers/2' row		Yield - bu/A	
		Tillering	Fully Tillered	Tillering	Fully Tillered
ACP-62-70A	1	57.8	60.2	52.7	54.3
ACP-62-70B	1/2	51.5	61.0	56.5	66.9
	2	46.5	58.5	57.5	65.7
ACP-62-177	1/2	52.2	58.0	50.6	45.9
	2	58.5	53.0	58.6	57.3
Check		53.8	58.2	55.6	58.5
Average		53.4	58.2	55.3	58.1

* Average of four replications.

Table 3. Responses of Wong barley to ioxynil formulations applied at tillering and fully tillered stages of growth (1962-1963).*

Formulation	Rate, lb/A	Tillers/2' row		Yield - bu/A	
		Tillering	Fully Tillered	Tillering	Fully Tillered
ACP-62-70A	1	46	54	50.6	77.2
ACP-62-70B	1/2	45	62	72.1	94.3
	2	39	51	68.6	83.0
ACP-62-177	1/2	54	57	73.5	80.0
	2	54	56	90.5	85.5
Check		48	62	80.2	97.3
Average		48	57	72.6	86.2

* Average of four replications.

Table 4. Yield responses of Pennoll wheat, Wong barley, and Clintland oats to formulations of ioxynil applied at fully tillered and late joint-early boot stages of growth (1963-1964).*

		Yield - Bu/A					
		Wheat		Barley		Oats	
Formulation	Rate, lb/A	Fully Tillered	Late joint-Early boot	Fully Tillered	Late joint-Early boot	Fully Tillered	Late joint-Early boot
ACP-63-303	1/4	54.5	58.2	73.2	64.2	39.1	28.3
	1/2	52.9	57.6	63.8	57.0	36.9	24.6
	1	53.0	52.8	70.8	53.3	39.3	27.8
	2	54.0	56.5	65.2	67.2	37.0	18.1
	4	60.2	44.0	70.0	47.5	34.1	15.8
Check		62.5		77.2		37.4	
Average		54.9	53.8	68.6	57.8	37.3	22.9

* Average of four replications.

In the 1962-1963 season stage of growth at time of treatment was the most significant factor. In both cereals, wheat and barley, numbers of tillers produced per 2 feet of row were significantly different from treatments applied at the two stages of growth. There were no significant differences in the yield of wheat; but stage of growth of barley at time of ioxynil application was significant with regard to reductions of yield as was treatment. From all indications the ACP-62-70A was more toxic to barley than was ACP-62-70B or ACP-62-177.

Height was not significantly affected by any of the treatments.

In the 1963-1964 season only one formulation was employed. Thus, the difference attributable to rate could be more readily evaluated in addition to those differences attributable to stage of growth at time of application. Wheat exhibited no significant differences in response, while oat yield was affected by stage of application and barley yield by both rate and rate x stage interactions. In all three crops there was a tendency for the stage of growth, late joint-early boot to be more susceptible to injury as measured by yield than the earlier fully tillered stage. In barley where both rate and the rate x stage interaction were significant, there were no discernable trends.

Table 5. Weed control and crop response due to ioxynil in Clintland oats (1963-1964). All treatments made with ACP-63-303.

Rate, lb/A	Weed Control				Crop Response	
	Broadleaves		Grasses			
	Stand[1]	Vigor[2]	Stand[1]	Vigor[2]	Stand	Vigor
Fully Tillered						
1/4	9.1	7.1	6.1	8.6	0.2	0.2
1/2	8.6	9.2	4.6	7.8	0.6	1.2
1	9.4	10.0	8.3	7.0	0.9	1.3
2	10.0	10.0	5.1	7.5	0.8	1.4
4	10.0	10.0	7.6	8.4	0.6	0.9
Late joint-early boot						
1/4	6.7	7.2	4.8	9.2	0.6	0.9
1/2	6.5	6.9	3.2	7.6	0.5	1.4
1	7.8	8.2	2.8	6.1	0.6	1.6
2	8.9	8.3	4.0	7.8	0.4	1.9
4	7.5	7.2	5.8	7.8	0.9	2.3

[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 - hedge mustard, chickweed, corn chamomile, lambsquarters, crabgrass, and barnyardgrass.

From this Table, it is evident that the control of broadleaves and grasses increased with increases in the amount of ioxynil applied and that the weed control was less efficient at the late joint-early boot stage than at the fully tillered stage. At rates of 1, 2, and 4 lb/A some blasting occurred.

Conclusions

1. Barley was less tolerant to ioxynil than wheat or oats.

2. Weed control was less effective on older weeds than on younger weeds.

3. Stage of growth is an important factor in determining crop response. The fully tillered stage was the least susceptible to ioxynil while the earlier stage, tillering, and the later stage, late joint-early boot were more susceptible to injury.

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THE EFFECTS OF VARIOUS SURFACTANTS ON THE HERBICIDAL ACTIVITY OF DIMETHYLARSINIC ACID

W. H. Tharrington, R. D. Ilnicki, and M. A. Sprague[1]

Many references occur in the literature concerning the use of surface active agents in combination with herbicides to increase the efficacy of herbicides (1-7). Many of the herbicides studied were of the growth-regulating type. Dimethylarsinic acid (cacodylic acid), an herbicide which appears to have considerable merit in lawn and pasture renovations, possesses contact activity as well as some growth-regulating activity. Just what effect do surfactants have on the nature of its activity was the scope of the investigations reported here.

Included in this presentation are discussions of three greenhouse experiments on several plant species treated with cacodylic acid solutions in combination with several surfactants.

Test species included soybeans (var. Kent), field corn (var. N.J. No. 9), and lambsquarters.

Since the nature of the experiments entailed different procedures, these will be discussed separately.

Experiments with Soybeans and Corn

Two experiments were conducted on these test species. One was exploratory in nature; the other was more extensive.

Methods and Materials

Quart cans were filled with a mixture of 1 part sand to 1 part soil. Mechanical analyses of this mixture indicated sand - 67.6%, silt - 16.0%, and clay - 16.4%. Five seeds of either corn or soybeans were seeded in each can, allowed to germinate, and thinned to two uniform plants per can. Cans of soybeans and corn were selected for groups of uniform plants to comprise replications. Three replications of each species were used in the exploratory experiment and four replications in the second experiment.

In the first experiments treatments were applied when soybeans were six inches tall and corn in the three-leaf stage. In the second experiment the test species were allowed to grow longer before treatment; soybeans were nine inches tall and corn was in the five- to six-leaf stage.

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Treatments were applied with an endless belt sprayer calibrated to deliver 40 gpa of spray solution. Prior to treatment the soil surface was covered with vermiculite. After treatment, the plants were allowed to dry, the vermiculite removed, and the treated plants were arranged into randomized complete blocks on a greenhouse bench.

Treatments consisted of all possible combinations of cacodylic acid at 0, 1, and 3 lb/A with surfactants at 0, 0.1, and 1.0% by volume.

Visual observations of plant injury were made periodically until harvest. These were made using the scale 0 to 10 where 0 = no effect and 10 = complete kill. Plants were harvested by cutting at the soil surface when maximum effect of the treatments was evident. Both green and dry weights were recorded.

In Table 1 are presented the chemical descriptions and proprietary names of the surfactants used.

Table 1. Description of surfactants used.

Surfactant (Proprietary name)	Chemical Description
Anionic	
G-3300	isopropyl amine salt of dodecyl benzine sulfonate
Nonionic	
Span 20	sorbitan monolaurate
NNO	glycerol mannitan laurate (mannitan coconut oil ester)
Tween 20	polyoxyethylene sorbitan monolaurate
G-3707	lauryl alcohol
Brij-30	polyoxyethylene lauryl ether

Results and Discussion

First trial yields of soybeans, as presented in Table 2, were especially encouraging since there appeared to be some protection of cacodylic acid injury by some surfactants while other surfactants seemed to increase injury. Injury to both corn and soybeans treated with G-3300 and Span-20 was less than injury in other surfactant-treated plants. Yields of soybeans were higher in plants treated with G-3300 and Span-20 than in untreated plants. Visual ratings proved to be a fair index of injury, as

ratings increased yields tended to be reduced. There were significant differences between surfactants and between rates of cacodylic acid as expressed by yield of both corn and soybeans. While significant differences in yield of corn were observed between surfactant concentrations, none could be detected in soybeans.

Results of the second trial summarized in Table 3 were different. With corn, no yield differences could be detected between rates of cacodylic acid, between surfactant, or between the various concentrations of surfactants. Significant differences in soybeans were observed in all three categories. The order of effectiveness of surfactants was different in the second test. The use of Span-20 gave very low yields in corn and the use of G-3300 gave very low yields in soybeans. No surfactant or surfactant concentration tended to reduce the injury of cacodylic acid. Conversely, all surfactants increased the injury by cacodylic acid at each concentration.

Summary

In greenhouse tests, six surfactants were used at 0.0, 0.1, and 1.0% by volume in combination with 0, 1, and 3 pounds per acre of cacodylic acid on soybeans and on corn. Although it was originally thought that protection from the contact injury of cacodylic acid was obtained in soybeans by certain surfactants, further work failed to support that conclusion.

Experiment with Lambsquarters (*Chenopodium album*)

Lambsquarters is a weed which is extremely resistant to applications of cacodylic acid. This experiment was conducted to determine if this resistance could be altered by the addition of surfactant to the spray solution and, are there any differences between surfactants.

Methods and Materials

Three stages of growth were selected to be tested. Following seeding and germination, the stands were reduced to five plants per can. Treatments were applied as previously described with the endless belt sprayer. Three replications were treated. Green weights and dry weights were not obtained since plants were allowed a maximum regrowth period to see if they would recover enough to produce seed.

Staggered planting dates allowed all three stages, 6-inch, 3-inch, and colyledon leaves only, to be treated simultaneously.

Visual observations were made periodically and injury recorded.

Surfactants used in this test were Tween-20, Span-20, and G-3707 at 0.5% concentration. Also included were ACL-206 FG, ACL-209 FG, and ACL-210 FG at 0.25% concentration. The difference in concentration was caused by a false assumption that the latter three were present as pure surfactants. These last three are blends of emulsifiers used in the food industry.

Rates of cacodylic acid applied were 0, 5, and 10 lb/A.

Results and Discussion

Visual ratings of injury of cotyledon-size plants were not as effective as similar ratings on larger plants. However, the ratings do show an increase in injury with the addition of surfactants (Table 4). The cotyledon-sized plants were injured by the herbicide without additions of any surfactant. The ratings show a continual increase in visible injury for a week. Plants were more resistant to injury as maturity increased. One surfactant, ACL-209, caused continuously noticeable injury without cacodylic acid. Plants treated with Tween-20 and G-3707 exhibited injury symptoms faster and to a greater degree than did other plants treated with other surfactants. No plants were killed, except in the colyledon stage. All, except the colyledon stage, were retained in the greenhouse for an extended period. All these recovered and produced seed, even though injury was so severe that regrowth came from just above the soil surface. After four days, the injury of ACL-209 treated plants was virtually equal to the injury of Tween-20 and G-3707 treated plants even though the concentration of the former was one half the latter two.

Summary

Lambsquarter plants of 6-inch, 3-inch, and colyledon leaves only were treated with cacodylic acid at 0, 5, and 10 lb/A. The spray solution contained 0.5% by volume of three surfactants and 0.25% by volume of three other surfactants. Increased injury was visibly noted with time after application, with increasing rate of cacodylic acid, and decreasing maturity of the plant. All plants in the 6-inch and 3-inch stages recovered from the injury and produced seed.

Table 2. First Trial.

Mean dry weight and injury of soybeans and corn as affected by surfactants, surfactant concentration, and cacodylic acid rate.

	Mean Soybean Yeild (grams)	Soybean* Injury Ratings (Average)	Mean Corn Yield (grams)	Corn* Injury Ratings (Average)
Surfactants				
G-3300	12.7	2.8	9.19	1.8
Span-20	12.2	3.7	8.86	3.1
NNO	12.0	4.0	8.04	3.6
(Check)	11.4	0.7	9.50	0.3
Tween-20	11.3	4.5	7.02	4.9
G-3707	11.3	6.0	8.19	3.3
Brij-30	11.0	6.1	8.00	3.0
LSD (.05)	.37		0.97	
LSD (.01)	N.S.		N.S.	
Surfactant Concentration				
0.0%	19.1	5.5	11.12	0.4
0.1%	20.8	6.1	10.33	2.4
1.0%	20.7	7.0	7.99	4.2
LSD (.05)	N.S.		0.95	
LSD (.01)	N.S.		1.36	
Cacodylic Acid Rate (lb/A)				
0	15.4	0.9	11.84	0.3
1	11.5	4.8	10.06	3.9
3	8.4	7.4	7.55	5.8
LSD (.05)	1.0		1.08	
LSD (.01)	1.4		1.54	

* Injury ratings based on the scale 0 - 10; 0 = no injury, 10 = complete kill. Each injury rating listed is the average injury of the same group of plants which gave the average yield listed.

Table 3. Second Trial.

Mean dry weight and injury of soybeans and corn as affected by surfactants, surfactant concentration, and cacodylic acid rate.

	Mean Soybean Yield (grams)	Soybean* Injury Ratings (Average)	Mean Corn Yield (grams)	Corn* Injury Ratings (Average)
Surfactants				
(Check)	29.3	0.6	43.6	0.2
NNO	27.4	3.6	42.1	0.7
Span-20	26.4	3.5	39.7	1.3
Brij-30	25.3	4.1	41.1	1.3
Tween-20	25.2	3.6	39.5	1.3
G-3707	24.2	3.6	41.6	1.8
G-3300	23.5	2.1	42.8	0.5
LSD (.05)	0.16		N.S.	
LSD (.01)	0.21		-	
Surfactant Concentration				
0.0%	35.5	0.3	51.2	0.8
0.1%	32.3	3.3	48.5	1.1
1.0%	27.4	5.5	48.3	1.3
LSD (.05)	-		N.S.	
LSD (.01)	1.04		N.S.	
Cacodylic Acid Rate (lb/A)				
0	32.3	0.7	48.5	0.3
1	31.4	3.0	49.1	0.7
3	25.2	4.9	48.6	2.3
LSD (.05)	1.08		N.S.	
LSD (.01)	1.44		N.S.	

* Injury ratings based on the scale 0 to 10; 0 = no injury, 10 = complete kill. Each injury rating listed is the average injury of the same group of plants which gave the average yield listed.

Table 5. Visual ratings* of Lambsquarter plants as affected by surfactant and cacodylic acid rate.

Surfactant % by volume	Rate of cacodylic acid lb/A	24 Hours after Treatment			48 Hours after Treatment			96 Hours after Treatment			168 Hours after Treatment		
		6"	3"	C	6"	3"	C	6"	3"	C	6"	3"	C
Tween-20	0	0.0	1.0	-	0.3	0.7	0.0	0.0	0.7	0.0	0.0	0.0	0.0
0.5	5	7.0	5.7	-	8.3	8.7	8.7	8.7	9.9	8.3	9.7	9.9	8.0
	10	7.7	7.0	-	9.0	9.0	9.0	9.0	9.9	9.7	9.9	9.9	9.7
Span-20	0	1.3	1.0	-	0.3	1.0	0.3	1.0	0.7	0.0	1.0	0.0	3.0
0.5	5	3.3	4.7	-	6.3	7.3	8.7	7.7	8.3	9.7	8.3	9.7	9.7
	10	3.0	5.7	-	5.3	8.3	9.0	7.3	9.7	9.0	8.0	9.9	8.3
G-3707	0	0.0	1.0	-	0.0	2.0	2.7	0.3	1.7	3.7	0.3	1.0	0.0
0.5	5	4.7	7.7	-	7.7	9.0	9.3	8.0	9.7	9.7	8.3	9.9	9.0
	10	8.7	9.0	-	9.0	9.7	9.3	8.7	9.9	9.9	9.0	9.9	9.7
ACL-206	0	0.0	0.0	-	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0
0.25	5	3.0	3.3	-	4.7	6.3	9.3	7.3	7.0	9.9	6.0	7.7	9.9
	10	3.3	5.0	-	5.7	8.7	8.3	7.7	9.3	9.3	8.0	9.9	9.7
ACL-209	0	0.3	1.3	-	1.7	2.0	1.7	1.0	2.0	0.0	1.0	2.0	0.0
0.25	5	5.7	5.7	-	7.0	8.7	9.0	8.0	9.7	9.0	8.7	9.9	8.3
	10	5.3	6.7	-	6.7	8.7	9.7	8.7	9.9	9.7	8.7	9.9	9.3
ACL-210	0	0.0	0.0	-	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0
0.25	5	2.7	4.0	-	4.7	5.0	9.0	5.0	6.7	9.7	6.7	7.3	9.7
	10	0.7	1.7	-	4.7	6.0	9.0	6.0	7.3	9.7	7.3	8.7	9.7
CHECK	0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	5	0.0	0.0	-	0.0	0.3	8.3	0.0	1.7	9.0	0.3	1.3	5.7
	10	0.0	0.0	-	0.0	0.7	8.3	0.0	1.0	9.7	0.3	1.3	8.3

* 0 = no damage; 10 = complete kill

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ENHANCING DIRECTED POST-EMERGENCE TREATMENTS IN CORN WITH SURFACTANTS

R. D. Ilnicki, W. H. Tharrington, J. F. Ellis, and E. J. Visinski[1/]

There is considerable evidence in the literature indicating that additions of a surface active agent (surfactant) to water dilutions of an herbicide can increase, decrease, or not affect the phytotoxicity of the herbicide when the herbicide solution is applied to weeds.

Many investigations have been conducted on the effects of surfactants on water-soluble herbicides which are applied post-emergence directly to weeds. Little information is recorded on the effects of surfactants on the relatively insoluble herbicides such as the N-phenylureas and s-triazines.

A preliminary investigations was conducted at this Station in which a bio degradable surfactant (ACL-209-FG) was added to 2,4-bis(isopropylamino)-6-methylmercapto-s-triazine (prometryne) dilutions for post-emergence weed control in corn. An increase in weed control activity was observed with no injury to corn.

This work was continued and expanded this past year to include an additional bio degradable surfactant and two additional herbicides along with prometryne. The two new herbicides employed were 2-chloro-4-ethylamino-6-isopropylamino-s-triazine (atrazine) and 3-(3,4-dichlorophenyl)-1 methoxy-1-methylurea (linuron). These were selected because of their importance as post-emergence herbicides for corn.

Materials and Methods

New Jersey No. 9 field corn was planted on May 19 at the Adelphia Research Center, New Jersey Agricultural Experiment Station, Freehold on Freehold sandy loam soil.

Four-row plots, 20 feet in length, were established to receive post-emergence applications of atrazine, prometryne, and linuron in combination with two surfactants. The surfactants employed were ACL-209-FG (ATLOX 209) and ACL-210-FG (ATLOX 210) which are blends of emulsifiers used in the food industry.

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On June 19, a little over a month after planting, applications of atrazine at 3/4 and 1½ lb/A, linuron at ½ lb/A, and prometryne at 2 lb/A were made in corn in combination with concentrations of 1 and 2% of the surfactants (v/v). Included, also, were rates of herbicide and surfactant checks, i.e., herbicide treatments applied without surfactants and surfactants without herbicides.

The treatments were applied with a knapsack sprayer equipped with a 2-nozzle boom and calibrated to deliver 40 gpa at 30 psi. Spray applications were directed to cover the weeds, which were approximately 18 inches tall, and to the base of the corn plants. Care was taken to avoid wetting too much of the corn stems and leaves but in order to get complete coverage of the weeds some wetting of the corn plants was unavoidable. Corn was approximately 31 inches tall to the tip of the longest leaf extended at this time. The three centers of the four-row plots were sprayed. There were four replications of each treatment and the design of the experiment was a randomized complete block.

The weed infestation was predominately pigweed (*Amaranthus retroflexus*) with some lambsquarters (*Chenopodium album*) and was of sufficient intensity to effect some drought stress in corn. The growing season was extremely dry.

Weed control ratings were made six days following spray application then again on July 1 and August 13 (mid-season). Ratings were made independently by two or three observers using the scale 0 to 10, where 0 = no control and 10 = complete control or kill. Notes on corn injury were also made on these dates.

The two center rows were harvested with a picker-sheller on October 19. Field weights were recorded and samples taken for moisture determination from each plot. All yield data were converted to bushels per acre at 15½% moisture. Yield data were analyzed statistically.

Results and Discussion

In Table 1 are summarized weed control data for three observation dates. Included here is also a summary of the yield data. From this table it can be seen that additions of surfactants increased the activity of all herbicides. This increase in herbicidal activity was evident as early as six days after spray applications on June 25.

The greatest initial activity was produced with prometryne in combination with AGI-210 at either concentration. With regard

Table 1. The effects of surfactants on the performance of three post-emergence herbicides for weed control in corn. Herbicides with surfactants applied on June 19. Ratings made on June 25, July 1, and August 13, 1964.[1]

Herbicide	Rate, lb/A	% Surfactant ACL-209	% Surfactant ACL-210	Weed Control - Broadleaves[2] June 25	July 1	Aug. 13	Yield, bu/A
Atrazine, 80W	3/4			4.4	4.3	3.9	78.8
	1½			5.2	6.3	6.2	84.5
	3/4	1		5.8	6.7	6.4	78.9
	3/4	2		6.0	7.2	8.3	84.5
	1½	1		7.2	7.2	7.3	85.2
	1½	2		8.0	8.0	7.9	80.7
	3/4		1	6.6	5.8	6.2	69.0
	3/4		2	7.6	7.0	6.8	77.0
	1½		1	7.3	7.8	7.7	86.7
	1½		2	8.1	8.4	8.9	85.4
Linuron, 50W	1/2			6.3	6.4	5.3	84.6
	1/2	1		7.3	6.8	7.0	82.8
	1/2	2		8.7	6.6	6.1	78.2
	1/2		1	8.0	5.6	5.3	87.9
	1/2		2	8.5	7.1	6.1	84.5
Prometryne, 80W	2			5.8	4.9	4.4	77.5
	2	1		7.9	7.4	6.6	83.2
	2	2		8.1	7.1	6.0	78.2
	2		1	8.3	6.8	6.3	73.7
	2		2	8.7	7.9	6.7	78.2
Check	-			0.0	0.0	0.0	73.7
	-			0.0	0.0	0.0	44.7
	-			0.0	0.0	0.0	68.1
	-			0.0	0.0	0.0	69.9
L.S.D. 0.05							5.8
0.01							8.5

[1] Average of four replications and 2 or 3 ratings per replication.

[2] Based on scale 0 to 10; 0 = no control; 10 = complete control.

combination with prometryne effected greater control of weeds than the 1% concentration. These same observations were applicable to linuron. Notwithstanding that atrazine toxicity to weeds was also increased with these surfactants the magnitude of the increases was not as great as with prometryne and linuron on this first date.

Some injury to corn was evident on the first observation date from prometryne and linuron treatments and these were much greater in plots where surfactants were used. There was no noticeable difference in the degree of injury from either surfactant but there was a difference in concentration of surfactant, the greater the concentration the greater the degree of injury. This injury was still present on the second observation date but not on the third observation date. This injury was produced in large measure by the unavoidable wetting of the corn plants with sprays at time of application. No surfactant treatment produced any injury to corn when used alone.

Observations made on the second date revealed that weed control was greatest in atrazine-treated plots. As anticipated weed control from the 1½ lb/A rate was greater than from the 3/4 lb/A rate. Atrazine toxicity to weeds was increased by both surfactants, ACL-210 promoting a greater increase than ACL-209. There was a difference between concentrations of surfactant also, the higher concentrations enhancing greater activity than the lower ones.

By mid-season (third observation date) the differences due to surfactants were not obvious with any herbicide. Weed control was still greatest in atrazine-treated plots, especially at the 1½ lb/A rate. In practice, rates above ½ lb/A of linuron and 2 lb/A of prometryne are required in order to have sufficient residual amounts on the soil, after initial knock-down, for weed control. Because there is a sufficient residual amount of atrazine on the soil when applied at 1½ lb/A this in large measure contributed to the difference between atrazine and the other herbicides.

Because the weeds were in association with corn for over a month and because of the extreme drought conditions that prevailed throughout the course of this experiment, differences in weed control from the herbicides and/or surfactants were not reflected in yields signficantly. Generally, there were trends toward increases in yield with increases in weed control, however.

When the yield data were analyzed as a factorial design, with herbicidal treatments without surfactants eliminated,

rate were not statistically significant; however, herbicide and herbicide x surfactant were significant. Significant increases in yield were produced by atrazine and linuron, and the high rate of atrazine and linuron with ACL-210.

Summary and Conclusions

Increases in herbicidal efficiency of atrazine, linuron, and prometryne may be obtained by the use of surfactants.

The bio degradable surfactants, ACL-209 (ATLOX 209) and ACL-210 (ATLOX 210) are capable of effecting increases with these herbicides.

Increases in herbicidal effectiveness would be greatly reflected in yield if applications of post-emergence herbicides are made much earlier in the season when weeds are small and before they attain their maximum competitive ability.

Acknowledgment

Acknowledgment is made to Frank S. Black of the Atlas Chemical Company, Wilmington, Delaware for supplying experimental quantities of ACL-209 and ACL-210 surfactants.

THE EFFECT OF ADJUVANTS ON THE ACTIVITY OF HERBICIDES FOR THE CONTROL OF QUACKGRASS (AGROPYRON REPENS)[1]

A.R. Putnam and S.K. Ries[2]

The effective control of quackgrass (Agropyron repens) in horticultural crops is still a serious problem. Any means of eradication that reduces the amount of highly phytotoxic herbicide necessary for weed control will increase the safety margin for crops.

In recent years much research has been conducted pertaining to the use of adjuvants and herbicide mixtures to obtain increased herbicidal action. Many compounds having surfactant properties have been evaluated for effect on the activity of systemic herbicides. Most of the work in this area has been carried out with crop plants. Jansen (4,5) studied the effects of many surfactants on the activity of amitrole, dalapon, 2,4-D and DNBP on corn and soybeans and found that they may increase, decrease, or have no effect on herbicide activity. Freed (3) reported that surfactants increased the absorption of amitrole in bean plants. Surfactants have increased the activity of diuron on established weeds in cotton and are used commercially (6).

The effectiveness of herbicides may also be increased by applying combinations of chemicals. The mixture of simazine and amitrole-T has resulted in increased control of quackgrass over that from applications of either chemical alone (2). Warren and Colby (8) reported increased activity of solan on crabgrass where low concentrations of paraquat were added.

MATERIALS AND METHODS

Several experiments were conducted in 1964 with quackgrass at several stages of growth on non-crop land and in orchards. A CO_2 powered small plot sprayer (7) was used to apply chemicals in randomized block experiments where plots were 100 sq feet in size with 3 replications. A logarithmic sprayer which delivered 6 half doses was built on the principle described by Cialone (1) and mounted on a lightweight sulky. Log plots were 300 sq feet in size with 2 replications. All chemicals applied with the conventional small plot sprayer were applied in a volume of 36 gpa. Chemicals applied with the log sprayer were applied in a volume of 45 gpa.

An experiment was designed to evaluate amitrole-T, paraquat, dimethoate (a systemic insecticide), Multifilm X-77[3] (a blended surfactant), and 9D 207[4] (an emulsifier) as adjuvants. These materials were applied with simazine and diuron at 2 lb/A on

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[1]Journal Article No. 3516 of the Michigan Agricultural Experiment Station.

[2]Department of Horticulture, Michigan State University, East Lansing, Michigan.

[3]Alkylarylpolyoxyethylene glycol, free fatty acids, isopropanol - supplied by Colloidal Products Company, Sausalito, California.

[4]Emulsifier supplied by American Oil Company, Whiting, Indiana.

established quackgrass sod under apple trees on May 1. The quackgrass was 4-6 inches high at the time of application. A similar test was applied on non-crop land on May 2 in which the previously listed materials in addition to several oils and the isooctyl ester of 2,4-D were evaluated.

A log trial testing the combination of 2 ureas and 2 triazines with paraquat and amitrole-T was applied May 29 on quackgrass 8-10 inches high. On June 16, treatments were applied on quackgrass, just starting to head, to study the effect of the addition of paraquat on simazine and amitrole-T. The experimental design utilized was a split plot with two times of application, mid-day and evening. A later test (July 22) was conducted on quackgrass regrowth which was 4-6 inches high after plowing. In this test, fuel oil, Surfactant WK[1], and paraquat were added to amitrole-T and compared with amitrole-T alone and other combinations of herbicides. The rates of surfactants and oils used were expressed as percent by volume. For the oil treatments, 9D 207 at 0.1 percent by volume was employed as an emulsifying agent.

Visual ratings were made on the plots throughout the season. A rating of 1 designated no control and 9 designated complete kill, whereas a rating of 6 was considered commercially practical quackgrass control. The log plots were rated at each half-dose interval and later ratings were made to determine the lowest rate at which commercial weed control was obtained.

RESULTS AND DISCUSSION

Visual ratings made on June 4 of quackgrass treatments applied under apple trees indicated that simazine or diuron at 2 lb/A combined with amitrole-T at 1/4 lb/A were the only chemicals in the test giving commercially acceptable weed control (Table 1). The combination of simazine with paraquat at 1/4 lb/A appeared more effective than either chemical alone. Dimethoate, Multifilm X-77 and 9D 207 did not increase the herbicidal activity of either simazine or diuron.

In a similar test at East Lansing, combinations of amitrole-T at 1/4 and 1/2 lb/A and simazine or diuron at 2 lb/A were more effective than either chemical alone (Table 2). Paraquat at 1/2 lb/A added to simazine and diuron gave similar results. Paraquat alone produced an initial knockdown, but regrowth was rapid. None of the surfactants or oils tested increased the herbicidal activity of either simazine or diuron sufficiently to give commercially acceptable quackgrass control.

Combinations of chemicals applied in log plots were effective in controlling quackgrass from May to September (Table 3). Amitrole-T and paraquat exhibited a similar enhancement of the activity of the triazines and ureas tested. Paraquat was more effective with simazine and diuron than with atrazine or linuron.

After observing the apparent enhancement of herbicide activity by paraquat, a test was conducted to determine if the response was influenced by time during the day of application. Paraquat at 1/4 lb/A added to simazine at 4 lb/A and amitrole-T at 1 lb/A

[1]Dodecyl ether of polyethylene supplied by E.I. DuPont & Company, Wilmington

gave increased control which was nearly additive from that of the control of each chemical alone (Table 4). There was no main effect or interaction effect with time of application. The mechanism by which paraquat increases the weed control obtained from other chemicals is not known. However, autoradiographs have indicated that paraquat increases the absorption of C^{14} labeled simazine by quackgrass leaves under greenhouse conditions.

Table 1. The effect of adjuvants on the activity of simazine and diuron on quackgrass control under apple trees.

Treatments		
Chemical	Rate (lb/A) % adjuvant (by volume)	Quackgrass control ratings 6/4
None	--	1.0
simazine	2	1.3
diuron	2	4.0
amitrole-T	1/4	4.3
paraquat	1/4	2.3
Multifilm X-77	.1%	1.3
dimethoate	.1%	1.0
9D 207	.1%	1.3
simazine + amitrole-T	2 + 1/4	6.7
simazine + paraquat	2 + 1/4	4.3
simazine + Multifilm X-77	2 + .1%	1.7
simazine + dimethoate	2 + .1%	1.7
simazine + 9D 207	2 + .1%	3.0
diuron + amitrole-T	2 + 1/4	6.7
diuron + paraquat	2 + 1/4	5.3
diuron + Multifilm X-77	2 + .1%	2.7
diuron + dimethoate	2 + .1%	3.3
diuron + 9D 207	2 + .1%	3.3
LSD at 5%		2.2
LSD at 1%		3.0
Coefficient of variation		44%

Where amitrole-T was sprayed alone or in combination with other chemicals on young quackgrass regrowth, adjuvants increased its effectiveness (Table 5). Fuel oil as a 10% and 1% emulsion increased the weed control obtained from amitrole-T observed on September 17. Surfactant WK at 1% was also effective. No injury was observed where the adjuvants were used alone. The addition of adjuvants to amitrole-T increased its long term effect to an extent which was comparable to the addition of 2 lb/A simazine + 1/2 lb/A paraquat in this one test. Increased control where adjuvants were used can probably be attributed to a better herbicide to leaf relationship both chemically and physically which results in more absorption. Autoradiographs have shown increased absorption of C^{14} labeled amitrole-T when a surfactant was added under greenhouse conditions.

Table 2. The effect of adjuvants on the activity of simazine and diuron on quackgrass.

Adjuvant	Rate (lb/A or % by volume)	Quackgrass control ratings: Adjuvants only	With simazine (2 lb/A)	With diuron (2 lb/A)
None	--		2.0	2.0
amitrole-T	1/4		6.7	7.3
amitrole-T	1/2		8.0	8.0
paraquat	1/4		3.7	2.7
paraquat	1/2		6.3	7.0
Multifilm X-77	.1%		1.7	2.0
dimethoate	.1%		2.3	2.3
9D 207[1]	.1%		3.3	2.0
L-53[1]	25%		3.3	2.7
LF 2670[1]	25%		2.0	2.7
LF 4340[1]	25%		2.7	1.7
LF 4247[1]	25%		2.3	3.0
LS 0799[1]	25%		2.3	3.3
isooctyl ester of 2,4-D[1]	1/4		2.7	2.3
isooctyl ester of 2,4-D[1]	1/2		2.0	1.7
corn oil	25%		2.7	2.0
olive oil	25%		3.3	2.7
amitrole-T	1/4	5.3		
amitrole-T	1/2	6.3		
paraquat	1/4	2.0		
paraquat	1/2	3.7		
LSD at 5%	(Including comparisons with		1.1	1.0
LSD at 1%	amitrole-T and paraquat)		1.5	1.3
Coefficient of variation			19%	17%

[1]Supplied by American Oil Company, Whiting, Indiana

Table 3. The effect of log sprays of triazines and substituted ureas combined with amitrole-T and paraquat on growth of quackgrass.

Chemical	Treatments: Initial conc (lb/A)	Lowest rate for commercial weed control: 6/19	7/13	9/17
simazine + amitrole-T	10 + 2	2.5 + .5	2.5 + .5	4.3 + .9
atrazine + amitrole-T	6 + 2	1.5 + .5	3 + 1	3.5 + 1.2
diuron + amitrole-T	10 + 2	2.5 + .5	5 + 1	4.7 + .9
linuron + amitrole-T	6 + 2	3 + 1	3 + 1	4.8 + 1.6
simazine + paraquat	10 + 2	2.5 + .5	5 + 1	3.1 + .6
atrazine + paraquat	6 + 2	1.5 + .5	1.5 + .5	4.0 + 1.3
diuron + paraquat	10 + 2	2.5 + .5	2.5 + .5	2.2 + .4
linuron + paraquat	6 + 2	1.5 + .5	6 + 2	5.9 + 2.0

Table 4. The effect of paraquat on enhancement of herbicide activity for quackgrass control.

Treatments		
Chemical	Rate	Quackgrass control ratings[1]
None	--	1.0
paraquat	1/4	2.2
paraquat + amitrole-T	1/4 + 1	6.9
paraquat + simazine	1/4 + 4	6.7
amitrole-T	1	4.7
simazine	4	3.2
LSD at 5%		0.7
LSD at 1%		1.0
Coefficient of variation		15%

[1]Mean of treatments applied at 1:00 p.m. and 8:30 p.m.

Table 5. The effect of adjuvants on the activity of amitrole-T for quackgrass control.

Treatments			
Chemical	Rate (lb/A or % by vol.)	Quackgrass control ratings 7/28	9/17
None	--	1.0	1.0
amitrole-T	1	4.0	5.7
amitrole-T + Surfactant WK	1 + 1%	4.3	7.3
amitrole-T + fuel oil	1 + 1%	4.7	7.3
amitrole-T + fuel oil	1 + 10%	4.7	7.3
amitrole-T + simazine + paraquat	1 + 2 + 1/2	7.7	6.3
amitrole-T + simazine + paraquat	1/2 + 2 + 1/4	6.0	3.0
paraquat	1/2	7.3	1.0
Surfactant WK	1%	2.0	1.0
fuel oil	1%	1.0	1.0
fuel oil	10%	1.0	1.0
simazine	2	1.0	1.0
LSD at 5%		1.4	1.4
LSD at 1%		2.0	2.0
Coefficient of variation		15%	13%

SUMMARY

Several field experiments were conducted with the objective of finding compounds which are effective in increasing the herbicidal activity of ureas, triazines and amitrole-T on quackgrass. Results varied with the stage of quackgrass growth at the time of application. The addition of low rates of paraquat and amitrole-T to atrazine, simazine, diuron, and linuron increased the weed control over that obtained from these chemicals alone. Paraquat was more effective with simazine or diuron than with atrazine or linuron.

The combination of paraquat and amitrole-T was more effective than either chemical alone. The mechanism of this enhancement effect is not known, but greenhouse studies indicated an increase in absorption of C^{14} labeled simazine when paraquat was added.

No oil or surfactant tested increased the activity of simazine or diuron at 2 lb/A to a degree which gave commercially acceptable weed control. Fuel oil and surfactants increased the activity of amitrole-T as shown by longer residual control of quackgrass.

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A PLOT DESIGN FOR STUDYING COMBINATIONS OF HERBICIDES

by

V. W. Woestemeyer and R. H. Cooper[1]

I. INTRODUCTION

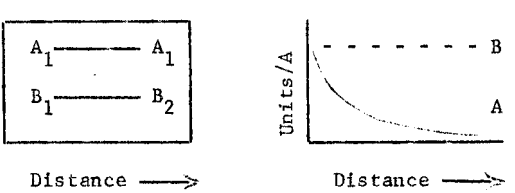
The increasing interest in, and use of, combinations of herbicides for solving many weed problems has led to the use of several techniques for the study of herbicide combinations in field plot tests. One of the simplest, although not always most satisfactory, is to select a few rates of each of two or more herbicides, based on knowledge at hand and intuition, as illustrated in Table I.

Table I

A_1 +	B_1
A_1 +	B_2
A_2 +	B_1
A_2	
	B_1
	B_2

Another technique is to apply one herbicide at one or more uniform rates, and apply the other herbicide at a logarithmic rate across each plot of the first herbicide (Figure 1)

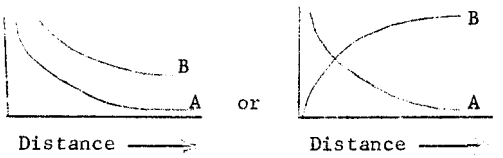
Figure 1



Still another technique involves logarithmic applications of both herbicides - either with both applied to a plot in the same direction, or applied in opposite directions (Figure 2).

[1] Agricultural Research & Development Department, U. S. Borax Research Corporation, 412 Crescent Way, Anaheim, California 92803

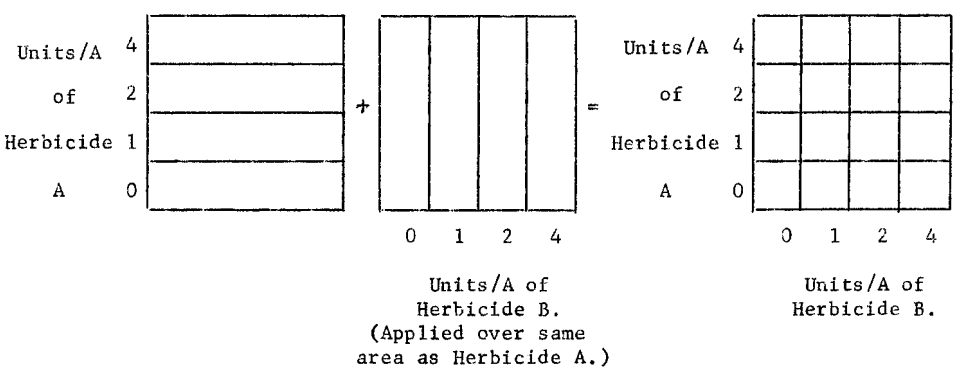
Figure 2



II. PROCEDURE

Each of the above procedures has a certain amount of utility. However, a procedure that has given us the most complete information for the time, effort, and materials expended utilizes a square design. The design consists of all possible combinations of selected levels of two herbicides. A systematic arrangement has a distinct advantage for visual evaluation (Figure 3).

Figure 3



A random arrangement within the block, supplemented by one or more additional replications of randomized blocks, would permit statistical analysis of the data.

III. RESULTS

Data in Figure 4, taken from an actual field test, illustrates a combination in which Herbicide B was not satisfactory alone at any rate used. Yet a low rate of this material reduced by 50 per cent the amount of Herbicide A required to achieve 95 per cent control of the vegetation.

Figure 4

Per Cent Control

Herbicide A Units/Acre	0	1	2	4	8
6	98	99	99	99	100
4	95	98	99	99	100
2	80	95	96	99	95
1	25	80	75	60	60
0	0	0	0	0	50

Herbicide B, Units/Acre

Data from another test with a different objective (Figure 5), showed a more scattered pattern in which 95 per cent or better control was obtained from three minimum combinations of herbicides A and B, respectively: Six units + 0 units, 4 + 1, and 2 + 8. With such data, and information on costs of the herbicides, the most economical combination providing a given per cent control can be determined.

Figure 5

Per Cent Control

Herbicide A Units/Acre	0	1	2	4	8
6	97	98	98	99	99
4	75	95	95	98	99
2	55	85	65	88	99
1	0	55	62	60	75
0	0	0	15	50	50

Herbicide B, Units/Acre

Figure 6 shows cost figures in a hypothetical case, using control figures from Figure 5.

Figure 6

Cost for 95-99 Per Cent Control

Herbicide A, Units/A. (Assume $2 per Unit).	0	1	2	4	8
6	$12				
4		$11			
2					$28
1					
0					

Herbicide B, Units/A.
(Assume $3 per Unit).

IV. SUMMARY AND CONCLUSIONS

The design is concluded to be useful for certain types of investigations of herbicide combinations.

A LABORATORY LOGARITHMIC SPRAYER

by

R. F. Crawford, Cecil W. LeFevre, and J. D. Stone[1]

I. INTRODUCTION

A small logarithmically diluting sprayer was designed and constructed for laboratory and greenhouse use. This sprayer was modeled after a field plot sprayer reported by Cialone, Bayer, and Sweet (1).

The concept and the protype of the portable, logarithmic sprayer was developed by H. G. van der Weij at the Institute for Biological and Chemical Research on Field Crops and Herbage, Wageningen, Netherlands.

II. RESULTS

The body of the sprayer was constructed of glass with teflon valves. The sprayer was operated by compressed air and the concentrated material was diluted and mixed by the turbulence of the air. Flats containing plants for treatment were transported through the spray on a small, electrically driven conveyer belt. The speed of the conveyer was regulated with a variable speed motor and rheostat. The sprayer was automatically started and stopped by an electrical switch which controlled a solenoid valve when the flat approached and passed under the spray pattern. The height of the sprayer could be adjusted with a scissor-type jack attached to the sprayer.

The accuracy of the logarithmic dilution was verified by spraying a dye and collecting samples at designated distances along the spray path. Concentration of the dye was determined by comparing the absorbance of the dye with known concentrations in a spectrophotometer. The observed change in concentration was found to be equal, within experimental error, to the theoretical dilution.

III. CONCLUSIONS

This sprayer has been useful in determining the potency of new herbicides. Rates for combining herbicides have been calculated and the optimum concentration of a particular surfactant to be added to a herbicide has been studied.

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[1] Agricultural Research & Development Department
U. S. Borax Research Corporation
412 Crescent Way
Anaheim, California 92803

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Seasonal Occurrence of *Echinochloa crusgalli* (L) Beauv. in Potato Fields in Connecticut River Valley, Massachusetts[1]

Jonas Vengris[2]

ABSTRACT

Seasonal occurrence of barnyardgrass (*Echinochloa crusgalli* (L) Beauv.) in potato fields was investigated in 1962, 1963 and 1964. Potato fields were surveyed semi-monthly during each growing season.

Barnyardgrass seedlings emerge as soon as potatoes or shortly after their emergence early in June. These seedlings are able to survive all the growing season. They usually survive on the top of the potato hills. Seedlings emerging before July 20 are able to produce mature seeds and thus serve as source for infestations of the fields in future years. Barnyardgrass seedlings emerge throughout the growing season and their abundance increases with the advancement of the season. Barnyardgrass plants in the field are more noticeable in August and later when the potato vines start to lodge and weeds increase in height.

Besides barnyardgrass in potato fields most abundant and common were: *Chenopodium spp.*, *Digitaria sanguinalis*, *Cyperus esculentus*, *Equisetum arvensis*, and *Amaranthus retroflexus*.

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[1]Contribution of Massachusetts Agricultural Experiment Station, Amherst, Mass.

[2]Associate Professor, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, Mass.

GREENHOUSE EVALUATION OF HERBICIDE COMBINATIONS[1]

S. R. Colby[2]

Increased attention is being focused on the use of herbicide combinations as a means of broadening selectivity, reducing residues, controlling perennial weeds, and improving the reliability of herbicide performance. The task of choosing which combinations to test is a difficult one. For example, if 20 herbicides were available to choose from, these could be combined in 190 different two-way combinations using only one rate of application of each herbicide. Obviously, a method is needed for selecting which of the many possible combinations to test.

The purpose of the following studies was to develop rapid and effective methods of testing herbicide combinations in the greenhouse, and to use the methods in developing selective herbicide combinations.

Materials and Methods

The following criteria were used in selecting herbicides to be combined. Combinations were made of herbicides: (1) Capable of controlling sufficiently different spectra of weeds, (2) showing outstanding selectivity on the same crop, (3) possessing different modes of phytotoxic action.

All tests were conducted in the greenhouse. Plants were grown in sterilized sandy loam soil in 3 1/2 inch plastic pots, with a single plant species per pot. The following plant species were used in one or more tests:

Glycine Max (L.) Merr., soybean, variety Clark
Zea Mays L. corn, variety Conn 870
Brassica campestris L., wild turnip
Amaranthus retroflexus L., pigweed
Digitaria sanguinalis (L.) Scop., large crabgrass
Ipomea hederacea (L.) Jacq., morning glory
Echinochloa crusgalli (L.) Beauv., barnyardgrass

Herbicides were applied preemergence or postemergence as sprays in 100 gpa of water. Preemergence applications were sprayed directly on the seed which had been sown on the soil surface. Immediately after spraying, the seed were covered with adequate soil to promote good germination and growth.

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[1] Contribution No. 3630 of the Maryland Agricultural Experiment Station, Department of Agronomy. Scientific Article No. A1159.

[2] Assistant Professor of Agronomy, University of Maryland, College Park.

This spraying method minimized selectivity due to depth protection by the soil. Each herbicide applied in a combination was also applied singly at the same rate as used in the combination. This was essential in determining the "expected" response of the combination. When available, commercially formulated herbicides were used; when not, technical grades were used.

Reductions in stand or fresh weight were used as criteria of herbicidal activity. Fresh weights were taken two to three weeks after herbicidal application. Synergism is considered here as an observed herbicidal activity greater than that expected. Expected activities were calculated according to the method described by Limpel, Schuldt and Lamont (2):

x= % weed control by herbicide A at p lb/A
y= % weed control by herbicide B at r lb/A
E= expected % weed control by A+B at p+r lb/A

$$E = x+y - \frac{xy}{100}$$

Extended to 3-way combinations:

z= % weed control by herbicide C at t lb/A
E= expected % weed control by A+B+C at p+r+t lb/A

$$E = x+y+z - \frac{(xy+xz+yz)}{100} + \frac{xyz}{10,000}$$

Results and Discussion

The preemergence activity of some herbicides and herbicide combinations against several weed species is shown in Tables 1 and 2. Note the relatively low rates of herbicides used. There were two reasons for using low rates. First, when herbicides were sprayed on the seed, less was required to achieve activity equivalent to surface applications. Secondly, high rates inhibit growth severely and render evaluation of the combinations difficult or impossible.

The results in Tables 1 and 2 show that many of the combinations effectively broadened the spectrum of weeds controlled. Soybeans were also included in these tests; but since no herbicide or combination injured them, the fresh weights are not shown. The average percent inhibition of all species was computed for each herbicide, and the resulting values were used in determining the observed and "expected" herbicidal activities of the combinations. The results are shown in Table 3. Also shown are the number of species controlled. This refers to a 50 percent reduction in stand or in fresh weight.

Several combinations were tested more thoroughly to evaluate possible synergistic action on a single weed species, crabgrass. Each herbicide was tested alone and in all possible two-way combinations with a second herbicide, using two rates of application of each. The data are shown in Table 4.

Bromacil - prometryne and bromacil - TH-052-H combinations were more consistently synergistic than the others. Other combinations were more often antagonistic or additive than synergistic. The bromacil-trifluralin combination which was effective in broadening the spectrum of weed species controlled was quite antagonistic in this test on crabgrass. Colby, Warren and Wojtaszek (1) have shown that combinations of bromacil with DNBP were highly antagonistic on crabgrass.

Increased use of herbicides coupled with reduced frequency of cultivating row crops appears to favor infestations of perennial weeds such as nutsedge and Johnsongrass. Herbicide combinations may provide a partial solution to this serious problem. Several herbicides were tested alone and in combination on nutsedge and corn. The treatments were applied postemergence on nutsedge and preemergence on both nutsedge and corn. Several of the herbicides and combinations were applied in dimethylsulfoxide (DMSO) or in a relatively non-phytotoxic oil[1]. The DMSO and oil were applied at the rate of 100 gpa. Results are shown in Table 5. The only treatments which injured corn were those including DMSO. However, EPTC in DMSO did not injure the corn for some reason. The oil alone with no herbicide showed selectivity between corn treated preemergence and nutsedge treated postemergence. In general only those treatments which included oil produced a significant reduction in the growth of nutsedge treated postemergence. However, EPTC in oil did not significantly reduce growth. When applied preemergence, the oil alone had little effect on nutsedge; but all herbicide treatments applied in oil were highly effective. The most effective treatment, both preemergence and postemergence, for nutsedge control was EPTC plus atrazine both applied in oil.

The presence of large reserves of foods in the nutlets probably accounts for the resistance of nutsedge to many herbicides. Possibly the translocation of these food reserves out of the nutlet and into the growing seedling interferes with movement of herbicides into the nutlets and roots. Young (4) found that oils moved from leaves into the roots and below ground storage organs of plants. Minshall and Helson (3) showed that the movement of oils in plants was confined to intercellular spaces. Therefore, the application of herbicides in oil may offer a possible route of entry into the roots despite the opposite translocation of foods to the shoots.

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[1] Orchec 792, Esso Research and Engineering Co., Linden, New Jersey

Conclusions

1. Herbicide combinations were highly effective in broadening the spectrum of selective weed control as compared to herbicides applied singly.

2. Combinations of EPTC and atrazine were effective in reducing the growth of nutsedge.

3. Oils need further investigation as possible carriers for herbicides used in nutsedge control.

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Table 1. Greenhouse evaluation of preemergence herbicides and herbicide combinations. Herbicides were applied in combination at the same rate as when used singly.

Herbicides	lb/A	Fresh weight per pot (grams) Wild turnip	Crab grass	Pigweed	Barnyard-Grass
Control	—	4.7	5.8	4.1	5.1
R-1607	1/4	5.4*	5.5	4.0	3.7
C-1983	1/8	4.2	4.9	3.9	5.0
Linuron	1/8	4.6	5.1	1.9**	5.5
CP-31393	1/4	4.1	4.9*	4.0	3.7*
Prometryne	1/4	4.9	5.4	4.3	5.5
Bromacil[1]	1/32	3.9**	5.7	4.0*	4.0*
Amiben	1/4	5.3	5.3	.4*	5.1
Trifluralin	1/8	5.7	3.3**	4.0	5.2
DNBP	1/4	5.2*	6.8	4.9	5.0
Diphenamid	1/2	5.7	1.3**	2.8	5.1
R-1607 + amiben		4.9	1.6**	.3*	2.2
C-19183 + diphenamid		5.0	2.3**	1.7	4.7
Linuron + trifluralin		5.3	1.6**	1.3**	1.5
Linuron + DNBP		4.7	5.7	2.9	4.2
CP-31393 + DNBP[1]		5.3	5.2*	4.0	3.8*
Prometryne + trifluralin[1]		4.8	1.5**	3.0	4.4
Prometryne + DNBP		4.8	6.3	4.9	5.7
Bromacil + trifluralin[1]		4.6**	3.0*	2.7	2.7*
Amiben + trifluralin		5.6	1.9*	1.0*	1.8
C-1983 + trifluralin		4.7	4.6	4.2	4.8
Amiben + DNBP		5.0	4.4	.7	3.7
Bromacil + DNBP		4.6**	5.9	4.7	5.8
Diphenamid + trifluralin		4.2	3.0*	.8	2.4**

[1] These treatments showed some activity against morning glory; the others did not.

* Estimated 50% reduction in stand.

** Estimated 90% reduction in stand.

Table 2. Greenhouse evaluation of preemergence herbicides and herbicide combinations. Herbicides were applied at the same rate in the combinations as when used singly.

		(Fresh weight per pot (grams)				
Herbicides	lb/A	Wild turnip	Crab-grass	Pigweed	Barnyard-grass	Morning glory
Control	—	3.6	3.4	2.7	5.3	5.0
DNBP	1/2	2.6	3.4	2.1*	4.3	3.7
Linuron	1/4	1.4**	3.3	.3**	4.7	4.5
Trifluralin	1/8	4.7	3.3	3.2	3.2	5.0
B-377	1/2	4.4	4.4	2.1	4.8	5.0
C-2059	1/4	2.9	2.6	.9**	3.0	5.2
CIPC	1/2	4.1	3.5	2.6	4.6	4.3
TH-052H	1/2	4.1	5.0	2.2*	4.6	5.3
NPA	1/2	2.7	4.3	1.8*	2.5	4.6
Bromacil	1/16	1.3**	2.6	.5**	2.2	3.2
Prometryne	1/2	3.7	2.3	2.1*	3.8	4.0
Linuron + trifluralin		.7**	.2**	.7*	2.1	4.9
Linuron + B-377		1.3*	2.4**	.1**	3.9	3.1
Trifluralin + C-2059		2.9*	.4**	.3**	1.4*	3.8
Trifluralin + TH-052H		4.6	.9*	.8*	2.1	3.6
B-377 + C-2059		2.0*	1.1*	.2*	1.6	3.2
B-377 + TH-052H		4.3	5.5	.9*	3.2	3.7
B-377 + bromacil		1.5*	3.0*	1.1*	2.0*	2.9
B-377 + prometryne		2.7	3.7	1.3*	3.2*	2.8*
Bromacil + TH-052H		.4**	.7*	.1**	1.1*	2.8
Bromacil + prometryne		.6**	.3**	.1**	.8*	2.3
DNBP + C-2059		1.4**	.6	.3**	2.3	3.7
DNBP + TH-052H		3.2*	3.8	.7**	4.4	4.2
DNBP + CIPC		2.8*	3.9	1.9	3.1*	2.2
DNBP + NPA		.9*	3.6	.5*	2.5*	3.0
CIPC + NPA		3.7	3.6	1.4	2.4	2.3
DNBP + CIPC + NPA		1.1*	2.9	1.0*	1.9	1.9

* Estimated 50% reduction in stand.
** Estimated 90% reduction in stand.

Table 3. Comparison of observed and "expected" herbicidal activity of some herbicide combinations. The combinations shown are the same as those in Tables 1 and 2.

Herbicide combination	% Reduction of fresh weight[1] Observed	Expected	Species Controlled[2]
Combinations from Table 1			
R-1607 + amiben	54	25	3
C-1983 + diphenamid	30	28	2
Linuron + trifluralin	49	19	3
Linuron + DNBP	12	15	1
CP-31393	6	14	2
Prometryne + trifluralin	28	5	2
Prometryne + DNBP	0	0	0
Bromacil + trifluralin	33	15	3
Amiben + trifluralin	47	25	3
C-1983 + DNBP	6	13	0
Amiben + DNBP	32	21	2
Bromacil + DNBP	0	11	1
Diphenamid + trifluralin	48	26	3
Combinations from Table 2			
Linuron + trifluralin	62	35	4
Linuron + B-377	51	35	2
Trifluralin + C-2059	59	30	4
Trifluralin + TH-052H	41	0	3
B-377 + C-2059	62	30	4
B-377 + TH-052H	10	0	1
B-377 + bromacil	47	53	4
B-377 + prometryne	30	20	3
Bromacil + TH-052H	77	51	4
Bromacil + prometryne	92	62	5
DNBP + C-2059	63	43	4
DNBP + TH-052H	21	19	2
DNBP + CIPC	27	22	3
DNBP + NPA	49	34	3
CIPC + NPA	30	21	3
DNBP+CIPC+NPA	55	36	4

1 Reduction in the average percent inhibition of fresh weight of all species.

2 Species controlled were those which were reduced 50% in stand or 50% in fresh weight. There were 4 species in Table 1 and 5 in Table 2.

Table 4. Evaluation of herbicide combinations on crabgrass.

Herbicide treatment		% Inhibition of fresh weight		
		Observed	Expected	Observed minus expected
Bromacil + prometryne				
1/16	0	30		
1/32	0	0		
0	1/2	0		
0	1/4	0		
1/16	1/2	90	30	+ 60
1/16	1/4	82	30	+ 52
1/32	1/2	47	0	+ 47
1/32	1/4	0	0	0
R-1607 + amiben				
1/2	0	7		
1/4	0	0		
0	1/2	87		
0	1/4	46		
1/2	1/2	73	88	- 15
1/2	1/4	31	50	- 19
1/4	1/2	59	87	- 28
1/4	1/4	58	46	+ 12
Bromacil + trifluralin				
1/16	0	30		
1/32	0	0		
0	1/4	100		
0	1/8	49		
1/16	1/4	96	100	- 4
1/16	1/8	23	64	- 41
1/32	1/4	95	100	- 5
1/32	1/8	0	49	- 49
Amiben + trifluralin				
1/2	0	87		
1/4	0	46		
0	1/4	100		
0	1/8	49		
1/2	1/4	100	100	0
1/2	1/8	94	93	+ 1
1/4	1/4	99	100	- 1
1/4	1/8	99	72	+ 27
Bromacil + TH-052H				
1/16	0	30		
1/32	0	0		
0	1/2	0		
0	1/4	0		
1/16	1/2	33	30	+ 3
1/16	1/4	60	30	+ 30
1/32	1/2	12	0	+ 12
1/32	1/4	0	0	0

Table 5. The effect of herbicides and herbicide combinations on nutsedge and corn. Herbicides were applied at the rate of 1 lb/A ai whether applied singly or in combination. Nutsedge plants for the postemergence treatments were 10-days-old when sprayed.

	Fresh weight per plant (grams)		
		Nutsedge	
Herbicide treatment	Corn	Postemergence	Preemergence
Control	1.4	.21	.26
CP 31393	1.1	.14	.27
R-1607	1.5	.31	.08
EPTC	1.4	.18	.10
R-4572	1.6	.22	.03
Atrazine	1.3	.16	.15
5793	1.5	.22	.11
DMSO[1]	.8	.13	.12
Oil[2]	1.3	.09	.29
R-4572 + 5793	1.5	.28	.02
EPTC in oil	1.5	.12	.01
EPTC in DMSO	1.4	.26	.09
5793 in DMSO	.8	.14	.13
EPTC + atrazine	1.0	.21	.04
Atrazine in oil	1.3	.07	.07
EPTC + atrazine in oil	1.7	.05	.01
LSD 5%	.6	.12	.10

[1] Dimethylsulfoxide

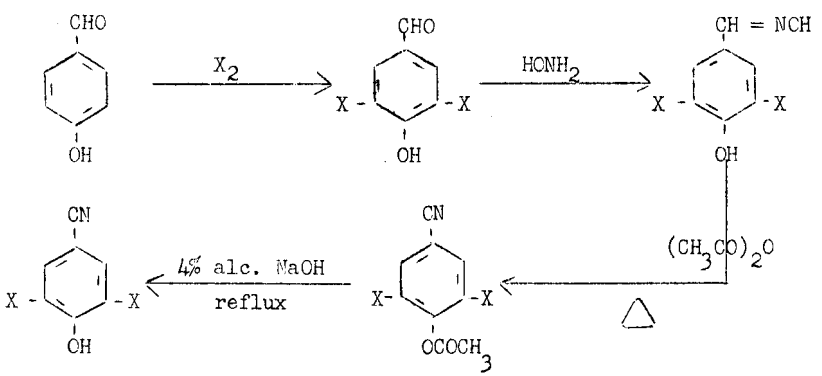
[2] Orchec 792, Esso Research and Engineering Co., Linden, New Jersey.

BIOLOGICAL ACTIVITY OF VARIOUS HALOGENATED DERIVATIVES OF IOXYNIL

A. R. Cooke, R. D. Hart, and N. E. Achuff[1]

Ioxynil (3,5-diiodo-4-hydroxy benzonitrile) is a new selective post-emergence herbicide for use in small grains. A number of crops, including wheat, corn, rye, barley, oats and sorghum, have outstanding tolerance of ioxynil at rates which will control annual broadleaf weeds. Some of the advantages of ioxynil over 2,4-D treatments are that this compound can be used in the fall of the year on fall planted grains. It will also control a number of weed species that are quite resistant to 2,4-D such as Amsinckia spp. (fiddleneck), Polygonum convolvulus (wild buckwheat) and Anthemis cotula (dog fennel). Also, ioxynil may be used where grains are underseeded with legumes whereas 2,4-D and MCP sprays cannot be used until the crop forms a protective canopy over the legumes.

Halogenated-4-hydroxy benzonitriles were first synthesized in Germany by Auwers and Reis (1896). They prepared the iodo, bromo, and chloro analogs by the following chemical route:



In 1960, personnel of Amchem Products, Inc., discovered the herbicidal activity of 3,5-diiodo-4-hydroxybenzonitrile (ioxynil). An extensive program of testing analogs, derivatives and related compounds was carried out during 1961, evaluating them on a number of weed species. This work revealed several compounds with appreciable herbicidal activity as is shown in Table 1. Only the diiodo and the dibromo analogs appear to have practical value.

[1] Agricultural Chemicals Division, Amchem Products, Inc., Ambler, Pennsylvania

Table 1. Summary of greenhouse comparison of the more active halogenated-4-hydroxybenzonitriles.

Test plant	Percent control - Post-emergence treatment at 2 lb/A				
	3-chloro	3,5-dichloro	3-bromo	3,5-dibromo	3,5-diiodo
Alfalfa	10	10	30	20	90
Corn	0	10	20	10	50
Avena fatua	0	10	50	20	50
Bromus tectorum	0	20	50	40	60
Setaria faberii	10	0	10	0	20
Echinochloa crusgalli	0	20	80	80	80
Digitaria sanguinalis	90	90	80	70	90
Sorgum halepense	0	20	30	10	30
Snapbeans	20	80	90	90	80
Barbarea vulgaris	100	100	100	100	100
Stellaria media	50	70	100	100	100
Soybeans	10	90	90	90	80
Abutilon theophrasti	100	100	100	100	100
Chenopodium album	90	90	100	100	100
Rumex crispus	50	90	100	100	100

The results obtained with the various mono- and dihalogenated analogs showed quite unexpectedly that the diiodo compound was the most active of this group. This is true whether the results are expressed on a weight basis or on an equivalent molar basis. The diiodo compound is more active than the dibromo which in turn is more active than the dichloro analog. At the higher rates (2 to 4 lb/A) all three of the dihalogenated analogs are somewhat similar in activity. The differences in activity show up particularly at the lower rates (1/8 to 2 lb/A). There is also a difference between the dihalogenated analogs in regard to the speed with which they kill weeds. The diiodo and the dibromo compounds are relatively slow in action and it often takes 4 to 5 days before the effect of these materials shows up on the test species. The dichloro analog, on the other hand, acts much more rapidly and gives a pronounced burn on the foliage within 24 hours.

The hydrolysis of ioxynil results in the formation of 3,5-diiodo-4-hydroxybenzamide and 3,5-diiodo-4-hydroxybenzoic acid. Both of these compounds are inactive. The corresponding benzaldehyde and hydrocinnamic acids are also inactive. Esters of ioxynil are active and on an equivalent basis are about equal in activity to the free phenol. A number of positional isomers have been investigated and have been shown to have a very low order of activity. Table 2 summarizes the comparison between structure and activity relationship.

Table 2. Comparative herbicidal activity of various halogenated derivatives of ioxynil

Compound	Relative activity
3,5-diiodo-4-hydroxy-benzonitrile	100
3,5-dibromo-4-hydroxy-benzonitrile	80 - 90
3,5-dichloro-4-hydroxy-benzonitrile	30 - 40
3-iodo-4-hydroxy-benzonitrile	25 - 35
3-bromo-4-hydroxy-benzonitrile	70 - 80
3-chloro-4-hydroxy-benzonitrile	15 - 25
p-hydroxy-benzonitrile	15 - 20
3,5-dinitro-4-hydroxy-benzonitrile	1 - 5
3-nitro-4-hydroxy-benzonitrile	5 - 10
3,5-diiodo-4-hydroxy-benzamide	0 - 1
3,5-diiodo-4-hydroxy-benzoic acid	0
2,6-diiodo-1-phenol-4-sulfonamide	0
3,5-diiodo-4-hydroxy-benzamidine	0
3,5-diiodo-4-hydroxy-benzaldehyde	1 - 5
3-iodo-p-anisaldehyde	0 - 1
3,5-dichloro-4-hydroxy-benzaldehyde	0
3,5-diiodo-4-hydroxy-benzaldehyde oxime	10 - 20
3,5-diiodo-4-hydroxy-hydrocinnamic acid	0
3,5-diiodo-4-hydroxy-benzonitrile, acetate	95 - 100
3,5-dibromo-4-hydroxy-benzonitrile, acetate	80 - 85
p-cyanophenoxy acetic acid	1 - 5
2,6-dibromo-4-cyanophenoxy acetic acid	15 - 25
2-chloro-4-cyanophenoxy acetic acid	5 - 10
3,5-diiodo-salicylonitrile	5 - 10

PROGRESS REPORT ON HERBICIDE TREATMENTS FOR THE CONTROL OF SPOTTED KNAPWEED (CENTAUREA MACULOSA)

Armin H. Furrer, Jr. and Stanford N. Fertig 1/

INTRODUCTION

Spotted knapweed (Centaurea maculosa)Lam., is in the family Compositae. Its duration may be biennial (1) or short lived perennial (2). It reproduces by seed and new shoots from old crowns. The plant is commonly found in dry, gravelly or sandy pastures, old fields, and roadsides (1).

This study was conducted to evaluate the effectiveness of control of several recently introduced herbicides in comparison with 2,4-D and 2,4,5-TP.

MATERIALS AND METHODS

On May 5, 1964, 13 chemical treatments plus a check (Table 1) were applied on a dense stand of spotted knapweed in an unimproved, grass pasture. The plants consisted of seedlings in the rosette stage and new shoots from the base of plants that had produced seed during the previous year. These rosettes averaged 2 to 4 inches in height and 3 to 6 inches in diameter at the time of treatment. Shoot elongation had started in a few plants. Treatments were replicated 4 times. The plot size was 6 by 20 feet. Herbicides were applied in 30 gallons of water per acre using a compressed gas, hand operated boom sprayer with carbon dioxide propellant. The weather was sunny, moderately windy and temperature 75 degrees F.

RESULTS AND DISCUSSION

Observations were made on June 5, June 26, Sept. 18, and Nov. 20, 1964. Table 1 shows the visual control ratings for spotted knapweed control made on Sept. 18.

Complete control of existing plants was obtained with 3 treatments: T-2, 2,4-D amine at 1.5 pounds per acre; T-4, 2,4-D low volatile ester at 1.5 pounds per acre; and T-7, Dicamba at 1.0 pound per acre.

Five treatments gave excellent control: T-1, 2,4-D amine at 0.75 pound per acre; T-3, 2,4-D low volatile ester at 0.75 pound per acre; T-5 and T-6, Dicamba at 0.25 and 0.5 pounds per acre respectively; and T-12, 2,4-D amine at 0.75 pound per acre plus Atlas 210 FG surfactant at 1 per cent of spray volume.

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Table 1

Treatments and Visual Control Ratings of
Spotted Knapweed (Centaurea maculosa)

Treatment No.	Chemical	Rate/A lb.a.i.	Visual Control Ratings* Spotted Knapweed Sept. 18, 1964 Average of 4 Reps.
1.	2,4-D amine	0.75	9
2.	2,4-D amine	1.5	10
3.	2,4-D low volatile ester	0.75	9+
4.	2,4-D low volatile ester	1.5	10
5.	Dicamba (Banvel-D)	0.25	9
6.	Dicamba (Banvel-D)	0.5	9+
7.	Dicamba (Banvel-D)	1.0	10
8.	2,4,5-TP	0.75	5+
9.	2,4,5-TP	1.5	7+
10.	Simazine (80W)	1.0	1
11.	GS-11362 (25W)	2.0	1
12.	2,4-D amine+surfactant**	0.75 + 1%	9+
13.	2,4,5-TP+surfactant**	0.75 + 1%	7
14.	Check	0.0	0

* 10=complete control
0=no control

** Atlas 210 FG

The following treatments gave unsatisfactory control: T-8 and T-9, 2,4,5-TP at 0.75 and 1.5 pounds per acre respectively; T-10, Simazine(80W) at 1.0 pound per acre; T-11, GS-11362(25W) at 2.0 pounds per acre; and T-13, 2,4,5-TP at 0.75 pound per acre plus Atlas 210 FG surfactant at 1 per cent of spray volume.

The addition of surfactant in treatments 12 and 13 (2,4-D amine and 2,4,5-TP each at 0.75 pounds per acre) gave only a slight increase in effectiveness over the same chemicals without surfactant, treatments 1 and 8.

Observations were made on Nov. 20 to determine the degree of re-infestation by seedling spotted knapweed plants in the test area. Very few seedlings were found in treatments 2, 4, and 7. These were the 3 treatments that were rated as giving complete control. Many spotted knapweed seedlings were found in treatments 10, 11, and in the check, treatment 14. It appeared that the density of seedlings present was roughly proportional to the density of mature plants that had produced seed in 1964.

A high percentage of plants that had produced seed in 1964 were forming basal rosettes.

SUMMARY

Spring treatments were applied on a grass pasture for the control of spotted knapweed. Three treatments gave complete control: 2,4-D amine and 2,4-D low volatile ester each at 1.5 pounds per acre, and Dicamba at 1.0 pound per acre.

Five treatments gave excellent control: 2,4-D amine and 2,4-D low volatile ester each at 0.75 pound per acre; Dicamba at 0.25 and 0.5 pounds per acre; and 2,4-D amine at 0.75 pound per acre plus surfactant Atlas 210 FG at 1 per cent of spray volume.

In this experiment, the addition of surfactant did not greatly increase the effectiveness of control.

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CORN CHAMOMILE (ANTHEMIS ARVENSIS L.) RESPONSES TO SOME BENZOIC ACID DERIVATIVES

Barbara M. Metzger, Judith K. Baldwin, and Richard D. Ilnicki[1]

The weed, Anthemis arvensis L., commonly known as corn chamomile, has become a pest in fall-seeded small grains, particularly in fields where no or limited crop rotation is practiced. Since both the weed and crops are winter annuals, seed germination, winter dormancy, and fruiting of the weed and crop species are concurrent. The similarity in life cycles coupled with the type of plantings of small grains prohibit mechanical approaches to weed control.

Ellis (1) in a recent life cycle study of corn chamomile determined that this species produces great numbers of seed. As many as 126,000 seeds per plant are not unusual. Furthermore, these seeds may germinate throughout most of the growing season making chemical control difficult.

Ilnicki (2) stated that injury to small grain is imminent when applications of herbicides currently in use are made at critical stages of growth at rates necessary to control corn chamomile. Prior to 1961, there was no efficient control of corn chamomile.

In 1960, two experimental compounds which subsequently were identified as substituted benzoic acids showed promise in the control of corn chamomile.

The growth-regulating capacity of benzoic acids has been known for twenty years and in the last ten years this family of compounds has been investigated for potential herbicides.

Koepfli, Thimann, and Went (3) defined certain molecular requirements necessary for growth-regulating capacities, namely (1) a ring system; (2) a double bond in the ring; (3) a side chain adjacent to the double bond; (4) a carboxyl group or a group readily converted to a carboxyl group on the side chain at least one carbon removed from the ring; and (5) a certain spatial relation between the ring and carboxyl group. Veldstra (6) simplified these requirements to a ring with a double bond plus a side chain with a carboxyl or a moity convertible to a carboxyl

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and a spatial relationship between the ring and the carboxyl group. The specific requirements for phenoxycarboxylic acids are well documented. However, those of benzoic acid derivatives are not. Veldstra further stated that for a benzoic acid derivative to be active in the pea curvature test or other standard tests for growth regulating activity, it must have diortho substitutions with molecules no larger than Cl or CH_4, the ring must have a high degree of surface activity, and an open para position. In addition, the meta substitutions must be such that they do not disrupt the balance between the hydrophilic and lipophilic elements of the molecule.

Muir and coworkers (5) going beyond the work of Veldstra expressed a belief that one of the two ortho positions must be free if activity is to be exhibited. Most recently, Minarik and coworkers (4) have evaluated certain halogen and anion substitutions. They concluded that substitutions in the 2, 3, and 5 positions were more effective than the 3, 4, and 5 substitutions and that the amount of activity in decreasing value conferred by halogen substitution was flourine, chlorine, bromine, and iodine.

Materials & Methods

Corn chamomile plants were removed from the field and were established in the greenhouse in a 1:1 sand to soil mixture, one plant to a pot. The experiment was a randomized block consisting of 22 treatments and four replications. The compounds applied were as follows:

1. 2-methoxy-3,6-dichlorobenzoic acid - dicamba
2. 2-methoxy-3,5,6-trichlorobenzoic acid - tricamba
3. 2,3,6-trichlorobenzoic acid - 2,3,6-TBA
4. 2,3,5,6-tetrachlorobenzoic acid - 2,3,5,6-TBA
5. 2-methyl-3,6-dichlorobenzoic acid - HN-1688
6. 2,3,6-trichloro-5-nitrobenzoic acid - HN-1763
7. 2,5-dichloro-3-nitrobenzoic acid - dinoben

Each compound was applied at rates of 1/4, 1/2, and 1 lb/A with an endless belt sprayer at 40 gpa in acetone as the carrier.

Detailed observations were recorded for the initial 15 days following treatment. After this period of time the condition of the plants appeared constant. However, they were kept on the greenhouse bench and watered daily for a period of three months to determine the long-term effect of the treatments.

Results and Discussion

The molecular structure requirements necessary for growth-regulating activity of benzoic acid derivatives were previously outlined. These structural requirements are based on standard growth tests which are not the same as phytotoxicity or herbicidal tests. The basic principles would be expected for both phyto-

Considering the seven compounds tested the following is the predicted order of increasing activity and why:

Predicted Order	Reason(s)
dinoben	lacks diortho substitution
HN-1763	hydrophilic balance upset by unequal meta substitutions
HN-1688	dissimilar ortho substitutions and unequal meta substitution
dicamba	dissimilar ortho substitutions but less severe than in HN-1688 and unequal meta substitution
2,3,6-TBA	unequal meta substitution
tricamba	all ortho and meta positions filled but unequally
2,3,5,6-TBA	all ortho and meta positions filled equally

In Table I are presented the predicted order of activities with those recorded at later dates for the compounds under study.

Table I. The predicted increasing order of activity compared with the order observed two weeks and three months after application.

Predicted	After 2 Weeks	After 3 Months
dinoben	HN-1763	HN-1763
HN-1763	dinoben	dinoben
HN-1688	HN-1688	tricamba
dicamba	2,3,6-TBA	HN-1688
2,3,6-TBA	tricamba	2,3,5,6-TBA
tricamba	dicamba	2,3,6-TBA
2,3,5,6-TBA	2,3,5,6-TBA	dicamba

Detailed responses at two weeks and three months after application are presented for each benzoic acid compound.

Two weeks after application:

HN-1763 - No visual symptoms appeared.

dinoben - Slow acting compound causing epinasty at all rates with some bleaching and dieback; however, there were some normal plants in all treatments with this compound.

HN-1688 - Compound effected erractic responses. In general each treatment caused epinastic and bleaching responses within four days, but at the end of the two-week period there were both normal and dead plants.

2,3,6-TBA - Compound was medium-fast acting which only produced moderate symptoms.

tricamba - Compound was fast acting and produced severe symptoms within 48 hours after application. No plants died during this period.

dicamba - Compound was fast acting and produced severe epinastic responses within 24 hours after application. Epinasty was followed by pronounced loss of color. Dieback was apparent at the fifth day but no plants died.

2,3,5,6-TBA - Compound was slow to act. Bleaching occurred three days after application with no prior epinasty. At the ninth day after application with no serious visual symptoms apparent, 50% of the plants were dead.

Three months after application:

The herbicidal activity did not parallel the initial phytotoxic activity. It would appear that those compounds which were initially fast acting were not as permanently injurious as the active but more slowly reacting compounds.

Conclusions

The basic structural requirements established by the early investigators of growth-regulating substance can only serve as a rough guide to the possible herbicidal activity of compounds. Those individuals concerned with determining activity must concern themselves with the long-term herbicidal effect as well as the immediately apparent, initial phytotoxicity.

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ANALYSIS OF POTATO, SWEET CORN, SNAP BEAN AND CARROT FOR RESIDUES OF AMIBEN[1]

C. E. Olney, T. W. Kerr, S. S. Scharf and R. S. Bell[2]

The compound amiben, 3-amino-2,5-dichlorobenzoic acid, is an herbicide that has been used for several years for the control of various weeds in plantings of vegetable crops. The investigation reported here was undertaken to determine whether measurable amounts of the herbicide would accumulate in crops, heretofore having no label approval, following application in the field. The crops included in the experiment were Katahdin potato, Carmelcross sweet corn, Long Tendergreen snap bean and Chantenay Red Cored carrot.

PROCEDURE

The potatoes analyzed were obtained from an experiment on herbicidal weed control reported by Bell and Kenyon (1) elsewhere in these proceedings. They were planted in a very fine sandy loam in late April, 1964, using four randomly replicated plots per treatment. The sweet corn, snap beans and carrots were planted in a similar type of soil on May 21, 1964. Four randomly replicated 25-foot rows, spaced four feet apart, for both amiben and check treatments of each vegetable were provided. The treatments and the amounts of amiben (active ingredient) applied either as 10% granules to the potatoes or sprays of 2-pound per gallon emulsifiable concentrate to the vegetables are presented in table 1. The pre-emergent treatment to the vegetables was made on May 23 and the layby treatment to the potatoes on June 26.

Harvest of the potatoes and vegetables took place as they matured during the season. From each replicate, in early September, approximately 10 pounds of potatoes were obtained at random from the grader as the yield from each treatment was being cleaned and graded. During October, fifteen tubers from each replicate were washed in tap water, halved lengthwise and one half of each potato selected and finely chopped. After mixing, a representative subsample was taken for residue analysis. The snap beans were picked, immediately placed in a polyethylene bag and frozen for later analysis. The carrot tops were removed and the roots washed in tap water to remove adhering soil. Like the snap beans, they were placed in plastic bags and frozen. Prior to analysis both the beans and carrots were finely chopped in a food chopper before analytical subsamples were taken. The representative field sample size from each of

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[1]Contribution #1129 from the Rhode Island Agricultural Experiment Station. A contribution from Regional Research Project NE-36.

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the four replicates was approximately 1050 grams of carrots and 500 grams of snap beans. The husk and silk from 15 ears of sweet corn in each replicate was removed and the kernels and cobs finely chopped, placed in plastic bags and frozen.

The residues were determined by a modification of the procedure for amiben in dried beans supplied by Amchem Products, Inc. (2). In the modified procedure a representative subsample was digested with alkali to release amiben from complexes with plant constituents. The mixture was then acidified and the 3-amino-2, 5-dichlorobenzoic acid extracted into ethyl ether. The amiben was re-extracted into sodium bicarbonate which was acidified and extracted with ethyl ether. The ether was evaporated and the sample methylated by refluxing overnight with methanol plus concentrated sulfuric acid as a catalyst. The resulting methyl ester was extracted with pentane and passed through Florisil. The amiben ester was then eluted from the column with benzene, the benzene evaporated and the sample partitioned between 10 ml of hexane and 1 ml of acetonitrile. Aliquots of the acetonitrile layer were injected into a gas chromatograph equipped with a 2% SE-52 plus 0.5% DEGS column and electron capture detector. The unknowns were evaluated by comparison with untreated samples fortified with amiben at the caustic hydrolysis step.

RESULTS

As indicated in table 1, at the rates applied small amounts of amiben were found in potatoes and snap beans, while in carrots and sweet corn there was less than 0.01 ppm, the limit of sensitivity of the analytical method.

Table 1. Residues of amiben in potatoes and several vegetables following application in various treatments. Kingston, R. I. 1964

Treatment	Crop	Active toxicant	Residue
		lb./A	ppm
Layby	Potato	4	0.06
		8	0.31
Pre-emergent	Snap bean	4	0.02
		8	0.05
Pre-emergent	Carrot	4	<0.01
		8	<0.01
Pre-emergent	Sweet corn	1	<0.01
		2	<0.01
		3	<0.01

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COMPETITION BETWEEN ALFALFA AND CRABGRASS GROWN UNDER VARIOUS LEVELS OF P AND K IN NUTRIENT SOLUTION[1]

P. E. Keeley and R. A. Peters[2]

Competition was observed in the following study by growing alfalfa and crabgrass seedlings either alone or in association in nutrient solution at various levels of P and K. Since plants compete with soil colloidal material for cations when grown in soil, this variable can be removed by using a nutrient solution. Also, all ions in solution can be assumed to be available for plant growth since insoluble compounds do not normally form in a controlled nutrient solution system.

METHODS AND MATERIALS

Experiments were conducted at the Agronomy Farm Greenhouse, Storrs, Connecticut, during the months of January through June, 1964. Supplemental light of 1500 f.c. was used giving a daylength of 16 hours. Temperature ranged from 70 $\pm$ 5° F for the months of January through March, 80 $\pm$ 5° F for April, and 90 $\pm$ 5° F for May and June. Duration of experiments was 25 $\pm$ 3 days.

Plants were grown in 2 liter vessels containing ½ strength Hoagland #1 nutrient solution, aerated constantly, and changed at the following intervals: 5, 4, and 3 days for experiments 1, 2 and 3, and 4, respectively. The species used in the study were alfalfa, Medicago sativa, and large crabgrass, Digitaria sanguinalis, or small crabgrass, Digitaria ischaemum. There were 4 plants of a species per vessel when grown alone or 2 plants of each species when grown in association. Seedlings grown in sand, watered with 1/10 strength Hoagland, were placed in 1/4 strength Hoagland nutrient solution at the age of 4 weeks. Treatment solutions were introduced 5 days later. When phosphorus and potassium levels were altered, potassium nitrate and magnesium nitrate were added, respectively, to maintain a potassium and nitrogen level similar to the control. Small amounts of magnesium nitrate were added to the control solution to keep the nitrogen level similar in all treatments. When phosphorus levels were lower than 1.5 ppm,

[1]This experiment was supported in part by Regional Project NE-42, Weed Life Cycles as Related to Weed Control in the Northeast.

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phosphoric acid was used as the phosphorus source. The pH varied from 5.1 for fresh nutrient solution to 7.0 at the time of change.

TABLE I P AND K LEVELS IN NUTRIENT SOLUTION

Level	P(ppm) Expt. 1	2	3	4	K(ppm) Expt. 1	2	3	4
P_1 K_1	1.5	1.2	.075	0.75	20	20	9.75	3.9
P_2 K_2	15	15	15	15	118	118	118	118

Roots and shoots were separated at time of harvest, rinsed with 0.01 N HCl and deionized water, and dried at 100° F. Dry weight was determined for root and shoot tissue. All plants were wet digested with nitric and perchloric acid. Phosphorus was determined by the Metavanadate method while potassium was determined by the flame photometer.

The removal of K from the nutrient solution, i.e., the amount of K taken up by the plant, was measured with a Beckman cation electrode.

RESULTS

Dry matter production, % P and K, and shoot/root ratios can be observed in Tables II, III, IV, and V.

Dry Matter Production

Large crabgrass plants at the time of harvest approached four times the size of alfalfa in some treatments.

Dry weight of alfalfa was not reduced by P_1K_2 and P_2K_1 levels while large crabgrass was reduced considerably. In association, however, large crabgrass increased while alfalfa decreased at the P_1 K_2 or P_1 K_1 level. Growth rate of large crabgrass in association with alfalfa increased independently at the P_2 K_2 and P_2 K_1 levels, i. e. crabgrass increased but alfalfa did not change in dry weight.

Small crabgrass was comparable in size to alfalfa. Small crabgrass dry matter production remained constant for all treatments when grown alone. When grown in association growth increased only slightly and independently of alfalfa at the P_2 K_2 and P_1 K_2 levels. Growth was reduced slightly at the P_2 K_1 level and remained unchanged at the P_1 K_1 level.

TABLES II & III EFFECT OF VARYING LEVELS OF P AND K IN NUTRIENT SOLUTION ON UPTAKE OF K AND DRY MATTER PRODUCTION

Treatment		Exp.1(S.crabgrass)			Exp.2(L.crabgrass)			Exp.3(L.crabgrass)			Exp.4(L.crabgrass)		
		% - K		Dry	% - K		Dry	% - K		Dry	% - K		Dry
Species	Nutrient Level	Total Plant	Shoot Root	Wgt/ Plant	Total Plant	Shoot Root	Wgt/ Plant	Total Plant	Shoot Root	Wgt/ Plant	Total Plant	Shoot Root	Wgt/ Plant
1.Alfalfa	P_2K_2	4.09	0.89	.75	4.44	0.89	.84	4.92	1.08	1.12	4.36	2.15	1.29
2.Crabgrass	P_2K_2	5.06	2.21	1.06	3.04	3.90	3.07	3.46	4.58	4.78	4.14	4.57	5.16
3.Alfalfa	P_2K_2	4.68	0.98	.81	2.43	1.47	0.83	3.49	1.41	1.18	4.16	1.50	1.05
+													
Crabgrass	P_2K_2	4.89	1.98	1.36	3.33	3.86	3.94	3.94	3.56	7.76	4.93	4.55	5.56
4.Alfalfa	P_1K_2	4.40	0.83	.77	4.28	1.03	0.76	4.41	1.72	0.54	4.27	0.89	1.31
5.Crabgrass	P_1K_2	4.79	1.84	.97	4.21	3.10	1.52	4.05	1.10	1.21	4.28	2.45	2.20
6.Alfalfa	P_1K_2	4.17	1.16	.79	2.91	1.65	0.46	3.56	2.44	0.34	2.85	1.22	0.88
+													
Crabgrass	P_1K_2	4.20	1.65	1.30	4.55	2.68	1.98	3.41	2.17	1.64	4.46	2.68	3.08
7.Alfalfa	P_2K_1	3.20	1.48	0.70	2.64	1.13	0.59	2.48	1.79	0.83	1.70	1.63	0.88
8.Crabgrass	P_2K_1	2.04	2.76	1.13	1.41	2.32	1.52	1.23	2.42	2.56	1.16	1.10	1.84
9.Alfalfa	P_2K_1	2.82	1.22	0.69	1.23	1.07	0.56	1.28	0.93	0.99	1.11	1.51	0.96
+													
Crabgrass	P_2K_1	2.73	2.93	0.84	1.41	1.98	2.47	0.99	1.26	3.69	1.09	2.05	2.49
10.Alfalfa	P_1K_1	2.20	1.27	0.79	2.28	2.17	0.64	2.76	1.16	0.49	1.33	1.58	1.02
11.Crabgrass	P_1K_1	2.12	2.70	1.02	1.27	2.71	1.38	1.76	2.66	1.23	.89	2.56	1.98
12.Alfalfa	P_1K_1	2.18	1.62	0.67	1.73	1.32	0.34	1.41	1.41	0.34	1.10	0.97	0.91
+													
Crabgrass	P_1K_1	1.83	2.40	1.01	1.50	2.03	1.95	2.50	3.06	1.50	0.92	2.16	2.55

TABLE IV AND V. EFFECT OF VARYING LEVELS IN NUTRIENT SOLUTION OF P AND K ON UPTAKE OF P AND DRY MATTER PRODUCTION

Treatment		Exp. 1(S.crabgrass)			Exp.2(L.crabgrass)			Exp.3(L.crabgrass)			Exp.4(L.crabgrass)		
	Nutrient	% - P		Dry	% - P		Dry	% - P		Dry	% - P		Dry
Species	Level	Total Plant	Shoot Root	Wgt/ Plant	Total Plant	Shoot Root	Wgt/ Plant	Total Plant	Shoot Root	Wgt/ Plant	Total Plant	Shoot Root	Wgt/ Plant
1.Alfalfa	P_2K_2	.50	0.52	.75	.64	0.75	.84	.57	0.54	1.29	.57	0.54	1.29
2.Crabgrass	P_2K_2	.64	1.03	1.06	.35	1.46	3.07	0.48	1.25	4.78	.47	1.19	5.16
3.Alfalfa +	P_2K_2	.59	0.73	.81	.32	0.71	0.83	0.41	0.67	1.18	.46	0.71	1.05
Crabgrass	P_2K_2	.67	1.08	1.36	.40	1.39	3.94	0.45	1.05	7.76	.51	0.95	5.56
4.Alfalfa	P_1K_2	.24	0.83	.77	.19	0.78	0.76	0.12	0.56	0.54	.17	0.60	1.31
5.Crabgrass	P_1K_2	.21	1.16	.97	.10	0.82	1.52	.07	0.50	1.21	.12	0.73	2.20
6.Alfalfa +	P_1K_2	.17	.62	.79	.11	0.71	0.46	.11	0.83	0.34	.13	0.71	0.88
Crabgrass	P_1K_2	.22	1.10	1.30	.12	0.85	1.98	.09	0.46	1.69	0.14	0.58	3.08
7.Alfalfa	P_2K_1	.68	0.72	0.70	.68	0.59	0.59	.58	.81	0.83	.58	0.62	0.88
8.Crabgrass	P_2K_1	.67	1.37	1.13	.57	2.40	1.52	.71	1.81	2.56	.78	1.53	1.84
9.Alfalfa +	P_2K_1	.65	0.70	0.69	.53	1.02	0.56	.55	0.85	0.99	.62	0.82	0.96
Crabgrass	P_2K_1	.76	1.36	0.84	.65	2.03	2.47	.62	1.14	3.69	.75	1.59	2.49
10.Alfalfa	P_1K_1	.29	0.53	0.79	.17	0.76	0.64	.11	1.56	0.49	.23	0.96	1.02
11.Crabgrass	P_1K_1	.19	1.05	1.02	.09	0.90	1.38	.08	0.55	1.23	.14	0.93	1.98
12.Alfalfa +	P_1K_1	.24	.89	0.67	.14	0.52	0.34	.11	0.44	0.34	.12	0.55	0.91
Crabgrass	P_1K_1	.23	1.20	1.01	.11	0.85	1.95	.09	0.58	1.50	.15	0.74	2.55

Phosphorus and Potassium Content of Tissue

Alfalfa contained a greater % P than large crabgrass when grown alone. This was most obvious at the P_1 K_1 level. In association with large crabgrass a small reduction of P occurred without an increase in large crabgrass.

Large crabgrass when grown alone accumulated the greatest amount of P at the P_2 K_1 level and K at the P_1 K_2 level. P and K accumulation at these levels did not occur for alfalfa.

Alfalfa contained a greater % K than large crabgrass when grown alone at the following levels: P_2 K_2, P_2 K_1, and P_1 K_1; however, at the P_1 K_2 level the % K was almost identical for alfalfa and large crabgrass.

As the % potassium of large crabgrass increased, the % potassium for alfalfa was reduced at the P2 K2, P_1 K_2, and P_1 K_1 levels. The greatest reduction in potassium for alfalfa occurred in association with large crabgrass at the P_2 K_1 level. This reduction occurred without an increase in % K of large crabgrass.

Alfalfa was nearly as competitive for P and K as small crabgrass and more competitive for K under the treatments P_1 K_2 and P_1 K_1.

Percentage of Phosphorus and Potassium Vs. Dry Matter Production

A small reduction in % P for alfalfa grown in association resulted in decreased dry matter production at the P_1 K_2 level. A considerable reduction of % K occurred in alfalfa without a reduction of dry matter when grown in association with large crabgrass at the P_2 K_1 level. The reduction at the P_1 K_2 and P_1 K_1 levels was associated with lower yields.

Phosphorus and Potassium Shoot/Root Ratios

Shoot/root ratios for phosphorus are greater for small crabgrass than alfalfa. Also potassium shoot/root ratios are greater for small crabgrass but this ratio increases when plants were grown in association with alfalfa, especially at the P_1 K_1 level. Greater phosphorus shoot/root ratios were observed for large crabgrass than for alfalfa. This ratio becomes more comparable or even greater for alfalfa at the P_1 K_2 and P_1 K_1 level. At the P_2 K_1 level alfalfa shoot/root ratios are smaller.

Potassium shoot/root ratios were greater for large crabgrass

than alfalfa especially at the P_2 K_2 level. At this level, the ratio approaches 4 times the value for alfalfa. This ratio, however, becomes more comparable as competition is increased by the association of large crabgrass.

DISCUSSION

Dry Matter Production

The morphology of alfalfa roots was not characteristic. They did not have a tap root system but were more fibrous. This may have been a factor in the competitive ability of alfalfa in absorbing nutrient ions from solution.

When grown alone, the % P and K of plant tissue and dry matter production of alfalfa was reduced proportionally less than crabgrass as the fertility levels were reduced below the control, P_2 K_2. In association, alfalfa dry matter production was severely restricted by the P_1 K_2 and P_1 K_1 levels. Dry matter production of alfalfa when grown alone or in association did not change at the P_2 K_1 level even though large crabgrass increased in dry weight when grown in association. Small crabgrass, in contrast to large crabgrass, decreased in dry weight when grown in association with alfalfa at the P_2 K_1 level. These results point out that P levels were more critical for alfalfa than K levels when grown in association. This can be observed in experiment 4 where the amount of K in solution was 10 times less than P.

TABLE VI

EFFECT OF VARYING LEVELS OF P AND K IN NUTRIENT SOLUTION ON UPTAKE OF K

Treatment		Uptake of K
Species	Nutrient Level	Meq. K/gm. Tissue
Alfalfa	P_2 K_2	3.92
L. Crabgrass	P_2 K_2	0.67
Alfalfa	P_1 K_2	3.12
L. Crabgrass	P_1 K_2	0.90
Alfalfa	P_2 K_1	0.18
L. Crabgrass	P_2 K_1	0.11
Alfalfa	P_1 K_1	0.59
L. Crabgrass	P_1 K_1	0.11

Large crabgrass competition in association is believed to have been due to a greater growth rate. Large crabgrass removed a greater total amount of K from solution even though its efficiency to take up K was small compared to alfalfa. (Table VI). The greater % P for alfalfa grown alone indicated also a greater uptake of P. The exception to this was at the P_2 K_1 level where P was accumulated in excess of control by large crabgrass.

Small crabgrass, having a comparable growth rate of alfalfa, appeared to compete little with alfalfa.

Phosphorus and Potassium Shoot/Root Ratios

P and K shoot/root observations indicate that in alfalfa greater amounts of P and K accumulated in root tissue but smaller amounts in tops as compared to crabgrass. This was most obvious at the control level. In general, shoot/root ratios become somewhat more comparable when plants are grown in association at the other treatment levels. This indicates that greater amounts of P and K are translocated to tops for alfalfa while greater amounts of P and K are accumulated in root tissue for crabgrass.

Percentage of Phosphorus and Potassium Vs. Dry Matter Production

The % P and K in plant tissue varies greatly without an accompanying reduction in dry matter, yet critical P and K levels can be observed for both large crabgrass and alfalfa. Normal growth rate of alfalfa continued until P levels dropped below .17%. A concentration of .12% P was accompanied by a sharp decrease in dry matter production. Large crabgrass at the P_1 K_2 and P_1 K_1 level was below the .12% level and may explain why dry matter production was restricted under these conditions.

When plants were grown alone at the P_2K_1 level, dry matter production was restricted when the tissue concentration of K reached 2.5% for alfalfa. No comparable values are available for large crabgrass, but dry matter production was reduced for large crabgrass when the tissue concentration reached 1.4% or less. The more critical limiting level observed for alfalfa could not be determined for large crabgrass in this experiment.

The higher K values for alfalfa as compared to large crabgrass indicate the greater ability of alfalfa to take up K when K is limiting. These low K values of large crabgrass, however, may be influenced by the removal of K from solution by the rapid growth of these plants, lowering the concentration of K considerably below the desired treatment level. A more constant replenishment would undoubtedly increase the tissue concentration of K_2, especially for large crabgrass.

SUMMARY

Dry matter production and % P and K of plant tissue remained more constant for alfalfa than large crabgrass when grown alone under the varying P and K levels.

In association an increase in dry matter for large crabgrass occurred independently of alfalfa when P and K nutrient solution levels remained high or K was low. The increase in dry weight under the low K level was not accompanied by an increase in % K of the plant tissue. A slight increase in K was observed, however, at the high K level.

When P was low, an increase in dry matter production for large crabgrass was accompanied by a decrease in alfalfa. The % P in plant tissue increased only slightly for large crabgrass at the high and low P levels.

The competitiveness of large crabgrass was probably due to its large growth rate rather than its efficience in taking up P and K. P and K shoot/root ratios were altered by the treatment levels but were effected oppositely for the two species.

INCIDENCE OF PHENOLIC COMPOUNDS IN DALAPON-TREATED QUACKGRASS [1].

T. R. Flanagan, A. R. Langille, and R. S. Davis [2].

The work of Flanagan and Langille in 1963 indicated the presence of an unknown compound in extracts of quackgrass rhizomes; this compound was identified as phenol.(1) At this same time, work was done to correlate this compound with seed germination inhibition, a phenomenon sometimes associated with quackgrass. Additionally, soil studies were conducted to determine whether there were observable differences in soil phenol levels between land infested with quackgrass and land not infested. Furthermore, soils from dalapon-sprayed quackgrass land were compared for phenol content with unsprayed quackgrass land.

Materials and methods.

Three experimental areas on the same soil type were selected for soil and rhizome sampling: one with a prolific stand of vigorous quackgrass, one with no quackgrass, and one with actively growing quackgrass which had been sprayed previously with replicated applications of the sodium salt of dalapon at 4 and 8 lb/A [3]. Ten-gram samples were collected in replicate from the first 6 in. of the soil from each plot, sieved, then each washed in small Buchner funnels with 100 ml absolute ethanol. The filtrate was collected and reduced to 5 ml by flash evaporation and suitable aliquots chromatographed on paper. Chromatography procedures have been reported earlier (1). The Rf values for the resultant spots were comparative to those determined from control papers spotted with a known sample of phenol. Undeveloped papers were matched with developed control papers and the suitable areas cut from the undeveloped papers, eluted with 5 ml ethanol, and the resultant extract examined by standard procedures on a Beckman DK-2 ultraviolet spectrophotometer.

To eliminate the possibility that microorganisms in the quackgrass-infested soil were responsible for the presence of phenol, rhizomes were grown *in vitro* according to the method devised by Johnson and Buchholtz (2). The single node rhizome sections were allowed to sprout and grow for 2 weeks before being sprayed with a 50,000 ppm solution of dalapon, applied at 1 cm Hg pressure for 5 seconds. Four days later, the rhizomes, shoots and attached proliferated roots, were removed from the 0.8% agar solution. The remaining agar was macerated, adjusted to pH 1.0 with N H_2SO_4, then steam distilled into 0.1 N NaOH from which it was extracted by a series of ether and alkaline solutions until finally concentrated in 0.1 N $NaHCO_3$ for the final step.

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2. Assistant Agronomist, Graduate Research Fellow, and Research Assistant, Vermont Agricultural Experiment Station, Burlington, Vt.

3. Supplied by the Dow Chemical Co., Midland, Mich.

One-half of the final solution was reacted with a 0 2% aqueous solution of p-nitrobenzenediazonium tetrafluoroborate (3); the other half was examined by ultraviolet spectrophotometry. The reaction between the phenol and the diazonium indicator produced a red color which was examined with a Bausch and Lomb spectronic-20 colorimeter at 470 mu. The ultraviolet spectrum provided verification of purity as well as a quantitative check against the colorimetric method.

To determine the inhibitory nature of quackgrass rhizome extracts, 1-in. sections were cut out of the chromatographic papers at spots where phenol was presumably located. These papers had been spotted with suitable soil extracts from unsprayed quackgrass plots, chromatographed, and dried without development. Controls of unspotted papers were similarly processed and thoroughly dried. The strips were placed in Petri dishes and 10 barley and 10 alfalfa seeds placed on each strip. These were maintained for 5 days in a moist condition in a s'andard germination chamber at 70 F.

Results and discussion.

Highest levels of phenol were recovered from the soil from the plots of quackgrass previously sprayed with dalapon at the 8 lb/A rate; phenol was recovered in ever-decreasing amounts respectively from the 4-pound-per-acre sprayed plots, the soil from under unsprayed quackgrass and from the soil uninfested with this weed (Fig. 1).

Phenol was found also in the agar extract from flasks in which quackgrass rhizomes had been planted and the emergent shoots treated with dalapon, while the agar extract from flasks containing unsprayed quackgrass had considerably less. The sensitivity of freshly prepared p-nitrobenzenediazonium tetraflusroborate, even at very low phenol concentrations, approached that of untraviolet spectrophotometry.

Seeds of both barley and alfalfa failed to germinate on phenol-containing sections of paper from chromatographed soil extracts, while normal germination occurred on sections of control papers. These germination test results seem to warrant additional studies before valid conclusions can be drawn. These indications, plus the confirmed presence of phenol as a constituent of normal quackgrass rhizomes, may mean that this toxic compound, overlooked by other investigators, is another explanation of the detrimental effect of quackgrass often noted on companion and succeeding crops.

Summary.

1. Previous studies utilizing chromatographic, ultraviolet, and infrared spectroscopy, plus other chemical tests, identified an unknown compound, present in quackgrass rhizomes, as phenol.

2. By means of ultraviolet and colorimetric tests, phenol was found in quackgrass-infested soil. The quantity of phenol present varied directly with the rate of dalapon applied to the quackgrass.

3. Significant amounts of phenol were observed in the agar medium of test-tube cultures of dalapon-treated quackgrass.

4. Phenol from extracts of quackgrass-infested soil apparently inhibited seed germination.

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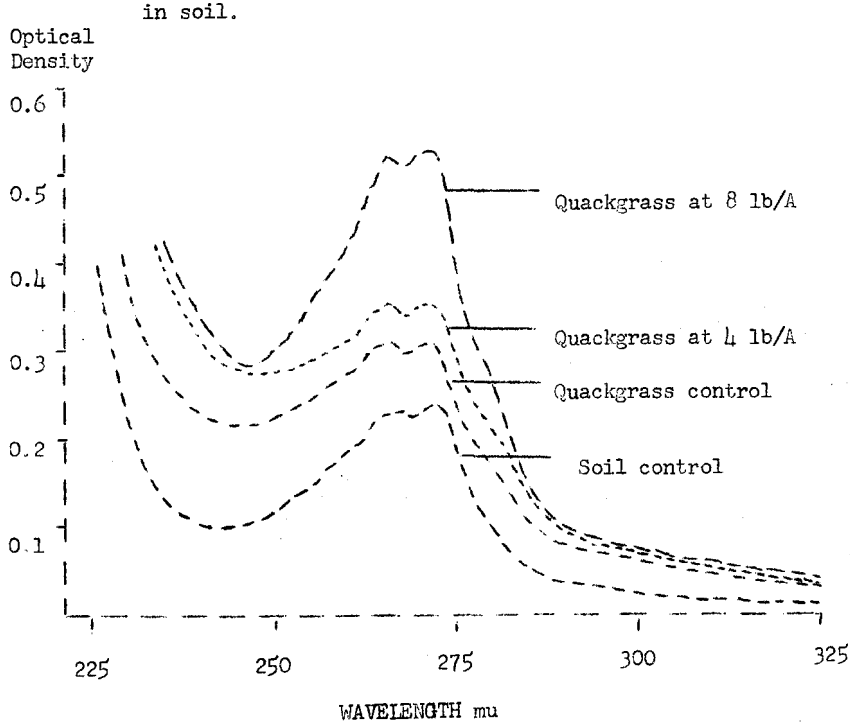
Figure 1 Ultraviolet absorption spectra showing levels of phenol in soil.



A METHOD FOR STUDYING THE RELATIONSHIP OF RAINFALL TO PRE-EMERGENCE HERBICIDE ACTIVITY

D. A. Brown and A. R. Cooke[1]

One factor influencing the success or failure of any pre-emergence herbicide is time and amount of rainfall following application. Hartley (2) stated that the importance of rainfall is undisputed and will vary with each herbicide due to solubility of herbicide, adsorption of herbicide in soil, moisture level of soil at time of application, and amount of evaporation between rains. iese and Davis (5) demonstrated the influence herbicide solubility has on herbicide movement in a Pullman silty clay loam soil following leaching with various amounts of water. Furtt, Meade, and Santelmann (3) observed the influence of soil moisture prior to simulated rainfall as related to CIPC movement in various soils. They showed original soil moisture did influence herbicide movement, and movement varied greatly within each soil depending on original moisture content. Rauser and Switzer (4) found similar results in work with amiben.

Most studies involving relationship of moisture and pre-emergence herbicidal activity have been conducted in the greenhouse under controlled conditions. Often this does not allow the plant to express itself as it would under field conditions. Colby (1) demonstrated the relationship of depth protection associated with the use of amiben in soybean production.

The present study was conducted to develop a method of determining how various herbicides, both experimental and commercial, may be affected by various amounts of rainfall under field conditions. Having developed this method, we now hope to determine how much rainfall is required to activate a given herbicide and at the same time how much moisture is required to leach the material out of the zone of weed control.

MATERIALS AND METHODS

All tests were conducted at Amchem Research Farm, Ambler, Pennsylvania. The soil at this site is classified as a Reaville silt loam which has a moisture content of approximately 28 percent when at field capacity. Prior to establishment of plots the area was rotovated to a depth of four inches and then rolled to place the soil in a condition that simulates field conditions at planting time. The area was then leveled to reduce run-off during the addition of water. Individual plots 12 ft. x 12 ft. were laid out with a 10 ft. border area between each. Corn and tomatoes were seeded in rows with a Planet Junior. The entire area was then overseeded with pigweed (Amaranthus retroflexus). Corn was seeded 1.5 in. deep and tomatoes .75 in. deep. The entire area was lightly raked to incorporate the pigweed seed.

Amiben at 3 lb active in 40 gal water per acre was applied to the soil surface with a small plot sprayer. Immediately following chemical application

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various amounts of water were applied with an arching fan-type lawn sprinkler. The output of this sprinkler is approximately one-half inch per hour. Water applied was measured by placing small containers around the edge of each plot and measuring amount of water trapped. Drainage ditches were dug around each plot to remove any run-off that occurred during watering, and to prevent water from running over the plots during rainy periods.

Following water application, A-frame structures 10 ft. x 11 ft. in size were placed over the plot, supported by metal rods driven vertically into the soil. These canopies were constructed of wooden frames and covered with polyethylene film. With the aid of adjustable clamps they were either placed flush with the soil or at a height of three feet above the plot, depending on prevailing weather conditions. Canopies were so constructed as to overlap at the top, allowing for ventilation and thus preventing high temperatures from developing when canopies were in a down position. Following initial water addition all canopies were placed over the plots and left there for two weeks. Canopies were then removed and evaluation made as to crop injury and weed control.

The use of polyethylene canopies to control moisture was adapted from a study conducted by Dr. R. J. Alderfer of Rutgers University concerning water requirements for plant production under field conditions.

RESULTS

Amiben	Water applied	Corn height(1)	Tomatoes	No. weeds/ 9 sq. in.(2)
3 lb/A	1 in.	7.5 in.	Stand severely reduced and stunted.	.75
3	2	10.1	Stand comparable to check but slightly stunted.	5.1
3	4	10.6	Good stand.	11.4
0	2	10.6	Good stand.	14.1
0(3)	2	10.9	Good stand.	15.8
3(3)	2	9.9	Stand count comparable to check but slightly stunted.	6.2

(1) Average of 10 measurements
(2) Average of 10 counts
(3) Plots not covered with canopies

DISCUSSION

Prior to addition of water the moisture content of soil was 7 percent in the top inch and progressed to 17 percent at the 4-inch depth.

The data indicates that when one inch of water was applied following treatment with 3 lbs of amiben and further moisture prevented from falling on plot for a period of two weeks, the amiben was distributed in the soil to a depth of at least two inches, indicated by the fact that all test species were affected by treatment. Pigweed and tomatoes, being seeded at depths of 0 to 0.5 and .75 inches respectively, were controlled very well. The tomato stand was reduced 90 percent, with surviving plants severely stunted. At this rate of amiben, corn planted 1.5 inches deep was also affected. No stand reduction was observed but stunting did occur.

With two inches of water following chemical treatment the amiben was probably moved to greater depth in the soil therefore diluting the amiben at any one point in the soil. Though amiben did remain in the top portion of soil to give fair pigweed control and stunt tomatoes. The population of tomatoes did not appear to be affected. Corn gave no indication of being affected in this plot.

When four inches of water was applied following chemical treatment it appeared that amiben was moved to such a depth and was so diluted that activity was drastically reduced. A slight amount of pigweed control was the only visible effect of treatment.

Two plots, a check given only 2 inches of water and the other treated with 3 lb/A of amiben and 2 inches of rain, were established without canopies. This was done to determine what effect the canopies might have on plant development. The canopies appeared to have very little effect on plant growth. The main reason for similarity between plots covered and those remaining open was due to lack of natural moisture during this particular test.

This experiment was repeated at a later date and the data collected was quite similar as to plant response.

SUMMARY

An experiment was conducted to evaluate under field conditions the possibility of using small canopies to study the relationship of moisture to the behavior of various pre-emergence herbicides.

The data indicates that the response obtained from amiben under field conditions may vary greatly due to amount of rainfall following application.

It appears this method will be quite useful in evaluating the influence of moisture on the pre-emergence activity of various experimental and commercial herbicides.

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SIMAZINE, ITS EFFECT ON NITRIFICATION AND ITS DECOMPOSITION BY SOIL MICROORGANISMS

F. H. Farmer, R. E. Benoit, and W. E. Chappell[1]

It has been widely reported that when herbicides are applied to soil at recommended field rates generally there is no harmful effect upon the soil microflora or its biochemical activity (Alexander, 1961). However, there are a few reports which suggest that the nitrifying bacteria are inhibited at concentrations of certain herbicides which do not affect the activities of other microorganisms. A number of workers have tested the effect of simazine (2-chloro-4,6-bis (ethylamino)-1,3,5-triazine) on nitrification (Burnside, et. al, 1961, Hauck and Stephenson, 1964, and Eno, 1962), but to date the results have been so contradictory that no definite conclusion can be made. The purpose of this investigation was (1) to determine the effect of simazine on pure and mixed cultures of the nitrifying bacteria, and (2) to attempt to isolate microorganisms from soil which can utilize simazine as a sole source of cellular carbon and nitrogen.

Methods and Materials

The soil perfusion unit developed by Lees and Quastel (1946) was used in the initial studies. A 0.01M solution of ammonium chloride was used as the substrate and a $CaCO_3$ buffer was used to maintain the pH at 8.0. The soil column in these units consisted of a 20 gram (dry weight) sample of a Lodi loam obtained from an alfalfa plot. Concentrations of 0, 1, 3, 6, and 9 ppm were added to the various units. A 4 ml sample was removed from the units every five days for the ammonium, nitrite, and nitrate analyses. The ammonium and the nitrate were determined by the distillation method of Bremner (1964), while nitrite was determined by the Griess method.

Pure cultures of *Nitrosomonas europaea* and *Nitrobacter agilis* were obtained from Dr. David Pramer of Rutgers University, and were grown in chemically defined media developed by Lewis and Pramer (1958). The cultures were grown in 250 ml Erlenmeyer flasks on a water bath shaker at 28°C. Simazine was added to the flasks at concentrations of 0, 1, and 6 ppm.

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Soil microorganisms which could utilize the herbicide as the sole source of carbon and nitrogen were obtained as follows: Lodi loam was enriched with a solution containing 250 ppm of simazine and maintained at field capacity for 45 days at room temperature. At the end of this period the soil was plated out on a medium similar to that used by Kaufman et. al. (1963), except that 1000 ppm of simazine was added as the substrate. Any colonies appearing on this medium were transferred by the streak culture method until pure cultures were obtained. The organisms which were able to grow after 7 successive transfers on the above mentioned medium were utilized for further studies. In solution culture studies of these organisms, simazine decomposition was determined by the colorimetric method of Ragab and McCollum (1961).

Results

In twenty days complete utilization of the ammonium was obtained in the perfusion controls. During this time a significant difference in the rate of ammonium oxidation was observed. Figure I shows that while the 1 ppm concentration of the herbicide does not appreciably effect the utilization, the 6 and 9 ppm concentrations produce a considerable inhibition. In a second study the perfusion experiment was repeated except that at the end of 20 and 40 days the ammonium concentration in all units was increased by 140 ug N/ml. The data are shown in Figure II. The inhibitory action of simazine on nitrification was pronounced during the 55 day duration of the experiment.

In the pure culture studies there was no significant difference between any of the cultures containing simazine and the control in the Nitrosomonas series, but in the Nitrobacter series, as can be seen in Figure 3, the 6 ppm concentration of simazine caused a distinct inhibition in the utilization of nitrite. Thus simazine seems to preferentially inhibit Nitrobacter without effecting Nitrosomonas.

These data are in agreement with data obtained in the perfusion studies. Amounts of nitrite as high as 40 ug N/ml were found in the units containing 6 and 9 ppm when their rate of ammonium utilization were the highest. This nitrite accumulation could be toxic to plants and to soil microorganisms if it reaches this level under field conditions.

Simazine has previously been reported to have no effect on nitrification; however, under our conditions a significant inhibition in the rate of nitrification was obtained. This discrepancy can be attributed to the methods used. Previous workers used the soil incubation technique, and it would appear that this method has certain limitations which can be eliminated by the perfusion method. The perfusion apparatus provides a method for continuous aeration of the soil, enables fresh substrate to be passed continuously down through the soil column, and since simazine has a low solubility in water this method maintains a uniform herbicide concentration in the liquid passing through the column. Furthermore, Keller (1961) has observed a similar inhibition in field studies.

In the simazine decomposition studies three fungi, two actinomycetes and two bacteria were isolated. Identification of these organisms and growth studies are presently being carried out in our laboratories.

Summary

Nitrification was carried out in perfusion units in the presence of varying concentrations of the herbicide simazine. Inhibition of nitrification was noted at concentrations of 6 ppm and above. A similar effect was noted with pure culture studies of Nitrobacter, but not with Nitrosomonas. Accumulation of nitrite in the perfusion units is indicative of this inhibition.

Isolation of seven organisms which can utilize simazine as a sole source of carbon and nitrogen was accomplished by soil enrichment followed by plating out of the soil. These organisms were able to survive seven transfers on a simazine medium.

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Figure I

Cumulative Utilization of Ammonium

(Series I)

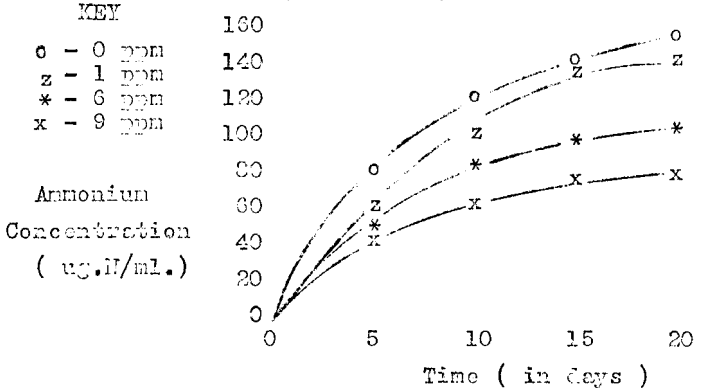


Figure II

Cumulative Utilization of Ammonium

(Series II)

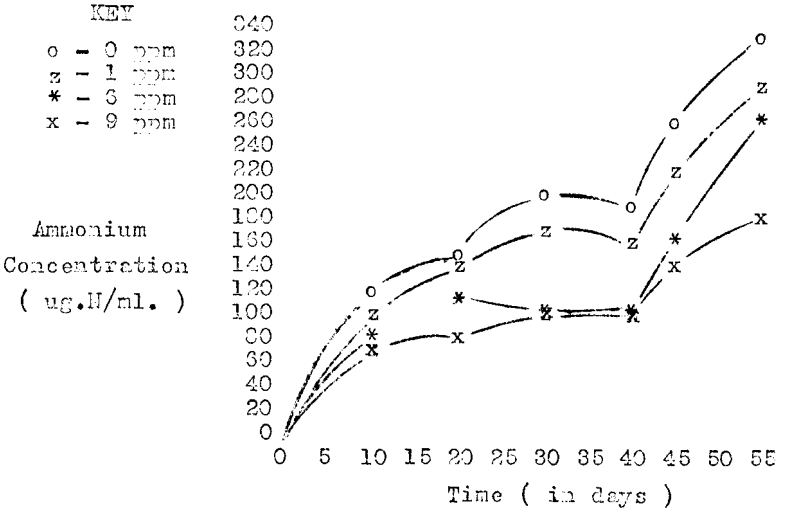
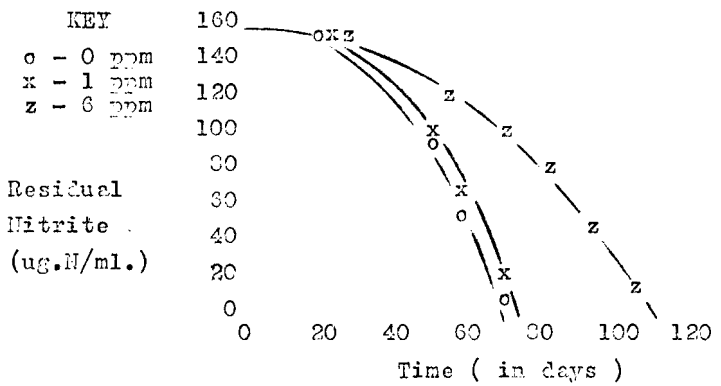


Figure III

The Effect of Simazine upon the Utilization of Nitrite by a Pure Culture of *Nitrobacter*



THE MOVEMENT OF SEVERAL FORMULATIONS OF EPTC IN SOIL

L. C. Liu and R. D. Ilnicki[1]

ABSTRACT

From preliminary studies conducted at this station it was observed that the initial as well as residual activities of two thiolcarbamate herbicides were increased when high boiling paraffinic hydrocarbon fractions were used as carriers.[2]

These studies are at present being continued to include greenhouse experiments for more critical examination of the effects of these carriers on the movement of ethyl N,N-di-n-propythiolcarbamate (EPTC) in soil.

Five formulations of EPTC dissolved in paraffinic hydrocarbon fractions having carbon numbers above C_{18} and designated EAP 4001, EAP 4002, EAP 4003, EAP 4004, and EAP 4005 were compared to commercially prepared EPTC (EPTAM). Soil columns were prepared and these leached with 1,3,6, and 12 surface inches of simulated rain following applications of 6 lb/A of all formulations on the surface of the columns. Kanota oats were used as the test species to bioassay the concentrations of the herbicides at various inch levels in the columns following leaching. Growth of oats, on a dry weight basis, was compared to oats grown in soil treated with concentrations of 1/128, 1/64, 1/32, 1/16, 1/8, 1/4, 1/2, 1, and 2 ppm of EPTC determine the concentration of the different depths of soil.

From these preliminary studies there appear to be differences between the experimental and commercial formulations. Generally, commercial EPTC is leached more easily and this was evident following leaching with one surface-inch of water. There appear to be differences in the experimental formulations as well, some being leached more easily than others.

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[2]R. D. Ilnicki, T. F. Tisdell, and R. W. Chase. Modified thiolcarbamate herbicides with broader utility. Proc. NEWCC 16: 362-370. 1962.

PERSISTENCE IN SOILS OF SEVERAL HERBICIDES USED FOR CORN AND SOYBEAN WEED CONTROL[1]

E. L. Wisk and R. H. Cole[2]

Persistence in soils of some herbicides is a growing problem associated with the use of these materials. The danger of injury to succeeding crops is constantly a threat and more information is needed regarding affects of chemicals on these crops. This is a summary of visual observations of the effects on succeeding crops of several corn and soybean herbicides used in the 1962 and 1963 Delaware weed control tests.

Procedure

Corn and soybean weed control tests were conducted in 1962 and 1963 at the University Substation, Georgetown, Delaware on a Norfolk sandy loam. Plot size was 18 feet by 50 feet. The crop varieties used were Kent soybeans, NE912 corn, Dubois winter oats, and Clinton spring oats.

After the corn and soybeans were harvested the soil was rototilled and seeded in winter oats. Injury ratings were made five weeks following planting. The soil was again rototilled the following spring and seeded in spring oats. Injury ratings were made four weeks later. Soybeans were then over-seeded and rated four weeks after emergence.

All plots were rototilled before seeding in an attempt to maximize the persistence of the materials and prevent soil movement among plots.

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Results and Discussion

Crop injury ratings (Tables I and II) indicate that the herbicides used in these tests at the given rates did not affect succeeding crops with a few exceptions. Granular Atrazine definitely caused severe injury to both fall and spring planted crops whereas Atrazine spray caused only slight injury to the fall seeded crop and none to the spring seeded crops. Trifluralin caused slight to severe damage to the fall seeded crop and only slight damage to the spring seeded oat crop. Slight damage to the fall planted cover crop was noted with diphenamid.

Some differences in weed species were observed the year following treatment but these were not fully evaluated. Consideration should be given to this aspect in future tests.

With the exception of granular Atrazine there was no damage noted on soybeans from herbicides applied to corn during the previous year. There was no damage noted on corn from any herbicides applied to soybeans the previous year.

Summary

Tests were conducted from 1962 to 1964 to determine the persistence in soils of several herbicides used in weed control tests in Delaware. Injury to some crops on land previouly treated with herbicides was observed.

Although diphenamid, trifluralin, and Atrazine caused some damage to the fall cover crop, only granular Atrazine caused severe damage to both fall and spring crops. Corn could safely be planted following soybeans treated with any of the soybean herbicides tested. Soybeans could be planted following Atrazine spray applications, but not granular Atrazine.

Acknowledgments

The authors wish to acknowledge the assistance of the herbicide manufacturers in making available the materials used in these tests and to thank them for their continued interest in this work.

TABLE I. Crop injury ratings* from herbicides applied in corn weed control tests at Georgetown, Delaware in 1962 and 1963.

Herbicide	Rate a.i. lbs/A	-Herbicides Applied Spring 1962 - Oats Planted Fall 1962	Oats Planted Spring 1963	Soybeans Planted Spring 1963	- Herbicides Applied Spring 1963 - Oats Planted Fall 1963	Oats Planted Spring 1964	Soybeans Planted Spring 19
Atrazine Spray	3	Slight	None	None	Slight	None	None
Atrazine Gran.	3	Severe	Severe	Severe	Severe	Severe	Severe

TABLE II. Crop injury ratings* from herbicides applied in soybean weed control tests at Georgetown, Delaware in 1962 and 1963. All materials were applied as sprays.

Herbicide	Rate a.i. lbs/A	- Herbicides Applied Spring 1962 - Oats Planted Fall 1962	Oats Planted Spring 1963	Corn Planted Spring 1963	- Herbicides Applied Spring 1963 Oats Planted Fall 1963	Oats Planted Spring 1964	Corn Planted Spring 19
DNBP	4-1/2	None	None	None	None	None	None
NaPCP	20	None	None	None	None	None	None
Amiben	3	None	None	None	None	None	None
Linuron	1	None	None	None	None	None	None
Prometryne	2	None	None	None	None	None	None
Diphenamid	4	Slight	None	None	Slight	None	None
Trifluralin (Inc.)	2	Slight	None	None	Severe	Slight	None
Vernam (Inc.)	4	None	None	None	None	None	None

*Slight - estimated small (not significant) reduction in stand and/or vigor.
Severe - estimated significant reduction in stand and yield.

Persistence of Several Herbicides in the Field

C. I. Harris and T. J. Sheets[1/]

Soil applications of herbicides have proven effective and are in wide use. However, injury to sensitive crops that follow those crops which have been treated with soil applications of certain herbicides has occasionally been observed. The purpose of this study was to evaluate further the persistence of several herbicides in soil.

The herbicides 3-(3,4-dichlorophenyl)-1,1-dimethylurea [diuron]; 2-chloro-4-ethylamino-6-isopropylamino-s-triazine [atrazine]; N,N-di-methyl-2,2-diphenylacetamide [diphenamid]; 2,3,6-trichlorophenylacetic acid [fenac]; and 2,4-bis(isopropylamino)-6-methylmercapto-s-triazine [prometryne] were applied to Wehadkee silt loam (pH 5.6, 25% clay, 1.9% organic matter, 10 meq. per 100 g. cation exchange capacity) on June 13, 1963. The soil was plowed, harrowed, and rolled prior to treatment. Formulated herbicides were used with water as the carrier, and applied with a knapsack sprayer at the rate of 30 gallons per acre. Treatments were replicated three times. Each herbicide was applied at a rate roughly equal to 1, 2, and 10 times the recommended commercial rate (Table 1). Treatments of the lowest rate for each herbicide were repeated on June 17, 1964.

One row each of oats (variety Clintonland) and soybeans (variety Lee) were planted lengthwise through each plot on each of 3 dates; September 27, 1963, May 12, and September 17, 1964. All plots were rototilled to a depth of approximately 5 inches before each planting. Five weeks after planting, vigor of oats and soybeans was rated in all plots.

Results and Discussion

Residue levels were reflected by the growth of oats and soybeans (Table 1). Because unfavorable weather in the fall of 1964 resulted in poor soybean growth, this crop was not rated. The untreated often had ratings higher than some of the treated plots. This probably resulted from the heavier weed growth on the untreated plots which tended to deplete both moisture and nutrient supplies.

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At the end of the first growing season following treatment only diphenamid and fenac were present in phytotoxic amounts at the low rate. Atrazine was also evident at the intermediate rate. All five herbicides were severely phytotoxic at the high rate.

One year after treatment the persistence pattern was nearly identical with that of the previous fall. The greatest difference occurred in the low and intermediate rate fenac plots where oats were no longer injured. Otherwise, there was only a slight reduction in phytotoxic effects in most plots that had been previously injured.

During the 1964 growing season the residue levels in the intermediate and high treatment plots changed greatly. By October 22, 1964 prometryne at the high rate showed no effects in two replications and only moderate injury in the third. Diuron and atrazine produced only mild effects in the high rate plots. Fenac and diphenamid were somewhat more phytotoxic than the other herbicides. In the intermediate plots, only diphenamid injured oats.

The long persistence of fenac and diphenamid is in agreement with previous reports. Dowler et al (1) reported that fenac at rates used for witchweed control, remained active in the soil and affected tobacco and cotton two years after application. Diphenamid was found at phytotoxic levels in tobacco soils by Jones et al 10 months after application (2).

The low rate plots were retreated on June 17, 1964 and the phytotoxic effects on October 22, 1964 were equal to or greater than they had been one year earlier. In the atrazine plots no injury had been evident from the low treatments a year earlier yet in 1964 more than a 50% reduction in growth was observed. Fenac also appeared to be more toxic to oats than it had been a year earlier. This difference in persistence may have been due to differences in rainfall. Total rainfall from May through September was 11.8 inches in 1964 and 21.2 inches in 1963. Previous reports (3, 4) have shown that the rate of dissipation is affected by soil moisture. One cannot rule out the possibility of some carryover of atrazine from the previous season, but the lack of any effect from atrazine in October, 1963, suggests that the amount carried over was very small.

Summary

Atrazine, diphenamid, diuron, fenac, and prometryne were applied in the field at three rates and their persistence evaluated. Diphenamid and fenac were most persistent, prometryne and diuron the least. Atrazine applied at 3 lb/A was much more persistent in a dry than in a moist season.

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Table 1. Crop Vigor Ratings[1]/ in Herbicide Persistence Plots.

Treatment	10-30-63		6-15-64		10-22-64
	Oats	Soybeans	Oats	Soybeans	Oats
Low Rates					
untreated	2.8	2.2	1.3	1.0	2.5
diuron, 1.5 lb/A	1.8	2.2	2.0	0.7	1.7
atrazine, 3 lb/A	1.7	1.0	0.7	0.7	6.5
diphenamid, 4 lb/A	7.7	3.2	6.7	2.0	7.0
fenac, 5 lb/A	4.0	8.3	0.7	7.0	6.7
prometryne, 4 lb/A	0.8	2.0	1.3	1.3	1.2
Medium Rates					
untreated	3.8	3.8	0.7	1.7	3.2
diuron, 3 lb/A	2.2	2.7	1.0	1.7	2.5
atrazine, 6 lb/A	6.3	4.3	4.3	3.7	2.5
diphenamid, 8 lb/A	9.3	4.3	6.0	1.7	5.0
fenac, 10 lb/A	5.5	9.0	1.3	8.7	1.0
prometryne, 8 lb/A	1.0	1.7	0.7	1.0	2.0
High Rates					
untreated	2.7	2.0	1.0	1.0	2.0
diuron, 15 lb/A	8.7	7.8	10.0	9.7	3.7
atrazine, 30 lb/A	10.0	8.0	10.0	10.0	4.0
diphenamid, 40 lb/A	10.0	7.7	10.0	8.3	9.2
fenac, 50 lb/A	7.8	10.0	8.0	10.0	5.0
prometryne 40 lb/A	9.7	8.0	10.0	6.3	1.7

PERSISTENCE OF ATRAZINE AND DIPHENAMID SOIL RESIDUES AND TOLERANCE OF THESE RESIDUES BY CERTAIN CROPS

Richard A. Ashley and E. M. Rahn[1]

Abstract[2]

Persistence of atrazine and diphenamid residues on soil was studied in field experiments in 1962, 1963, and 1964. Varying rates, times of application, formulations, and cultural practices were studied. Residues were determined on October 1 and March 1 of each year using oat bioassays. Field experiments were conducted to determine the tolerance of various crop plants to these residues.

Considerable variation was noted from year to year in the amount of atrazine and diphenamid persisting.

When atrazine was applied to a Matawan sandy loam soil at the recommended rate of 2 lb/A in late April, the approximate amounts in the soil in October were as much as 0.04 lb/A at 0-4 inches and 0.05 lb/A at 4-8 inches. When the rate of application was increased to 4 lb/A, comparable figures were 0.10 lb/A and 0.7 lb/A respectively. While the following March sampling found no persistence from the 2 lb/A application, there was still 0.07 lb/A remaining at 0-4 inches from the 4 lb/A application. Similar treatments on a Matapeake silt loam soil resulted in greater amounts persisting but caused less injury to the fall planted cover crop.

When diphenamid was applied to a Matawan sandy loam soil at the recommended rate, 3 3/4 lb/A in mid July, there was no appreciable persistence at the October sampling. When a 5 lb/A application was made, the approximate amounts in the soil in October were as much as 1 lb/A at 0-4 inches and 0.49 lb/A at 4-8 inches. Corresponding values for the March 1 sampling were 0.12 lb/A and 0.22 lb/A respectively.

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2. Paper to be submitted to Weeds.

Persistence of both atrazine and diphenamid was increased by delay of application beyond normal application dates. Persistence of atrazine was much greater where the granular formulation, rather than the wettable powder was used.

The following had little effect on atrazine persistence: frequent cultivation; plowing rather than discing prior to seeding cover crop; and growing of tolerant crops such as corn and hungarian millet in late summer to metabolize residues. Irrigation decreased persistence of diphenamid while plowing rather than discing prior to cover crops had no effect. The effect of cultivation on diphenamid persistence and irrigation on atrazine persistence was variable.

Eight vegetable crops and 6 cover crops were planted on plots where atrazine was logged on from 0.20 lb/A down. The soil was Matawan sandy loam. Of the vegetable crops, peas, lima beans, snap beans, cucumbers, and peppers showed visible injury symptoms at the higher rates, while potatoes, cabbage and tomatoes appeared uninjured. With the 6 cover crops, visual injury symptoms occurred on all cover crops at the higher rates, but there was no stand reduction.

Six cover crop plants were seeded on ground treated with diphenamid logged from 1 lb/A down. Wheat was found to be the most tolerant. The maximum rate tolerated by the cover crops were as follows: wheat, 0.52 lb/A; rye, 0.36 lb/A; barley, 0.26 lb/A; crimson clover 0.24 lb/A, ryegrass 0.24 lb/A, oats 0.15 lb/A.

Detoxification of Simazine- and Atrazine-Treated Soil With Activated Carbon (Abstract)

J. F. Ahrens[1]

Experiments in Europe and at this laboratory have shown that activated carbon can adsorb simazine [2-chloro-4,6-bis(ethylamino)-s-triazine] residues in soils and protect crops from injury. Amounts of activated carbon 100 to 400 times greater than applied amounts of simazine protected seeded oats and tomato plants in the greenhouse and oats in the field. In recent greenhouse experiments soil treated with atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) similarly was made non-toxic to oats by activated carbon.

The objectives of field experiments in 1964 were (a) to determine whether carbon/simazine or carbon/atrazine ratios of 200/1 and 400/1 could protect certain seeded and transplanted crops from residues of these herbicides, and (b) to compare methods of applying the activated carbon.

Simazine was applied in June at 1/4, 1/2, 3/4, 1 and 2 lbs. per acre and double-disked into the sandy loam soil. Activated carbon,[2] diluted with soil, was applied by hand uniformly over replicated plot areas and then double-disked into the soil. Within 2 weeks, Bountiful beans and Detroit Dark Red garden beets were seeded and Havana Seed tobacco was transplanted into the plots. A similar procedure was used in an experiment with atrazine, started in July, except that only 1/2 and 1 lb. of atrazine was applied and the carbon was broadcast in a water suspension as well as in dry form. In addition, Danish Ballhead cabbage was included in this experiment. The protective action of activated carbon was tested by adding it to the water used in transplanting tobacco and cabbage.

Crop sensitivity to simazine and atrazine, increased in the following order: cabbage, tobacco, beans and beets. On soil treated with atrazine or simazine at rates of 1 lb. per acre or less, a ratio of 200 parts of carbon to 1 part of herbicide afforded appreciable protection to beans, tobacco and cabbage. Here the yield reductions were usually less than 15% in beans and cabbage and 10% in tobacco. On soil treated with simazine at 2 lbs. per acre, however, a carbon/herbicide ratio of 400/1 (800 lbs. of carbon per acre) was necessary to reduce injury in all crops to low levels. Regardless of herbicides or rates, only the higher ratio of carbon to herbicide protected beets adequately.

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[2] Aqua-Nuchar - West Virginia Pulp and Paper Co.

There was no consistent difference between broadcast applications of dry or water-suspended activated carbon in protecting cabbage and tobacco transplants from atrazine injury. However, dry carbon was more effective than the water suspension in protecting beans or beets. Possible reasons for this difference will be discussed.

Activated carbon in transplant water greatly reduced injury to cabbage and tobacco plants set in soil containing toxic residues of atrazine or simazine. Atrazine at 1/2 lb. per acre reduced yields of cabbage 60 to 80%. Cabbage growing in these same plots but with activated carbon added to the transplant water (1 to 2% w/w), gave reduced yields of no more than 13%. This activated carbon treatment was not so effective when the atrazine rate was 1 lb. per acre.

Activated charcoal appears very promising for the inactivation of triazine residues that can be troublesome in crop rotations.

Improving Herbicide Selectivity in Horticultural Crops With Activated Carbon (Abstract)

J. F. Ahrens[1]

A pre-planting root dip in activated carbon was tested to see if it could protect transplants from post-planting applications of simazine /2-chloro-4,6-bis(ethylamino)-s-triazine/. The roots of half the plants in each plot were moistened and dipped into pulverized, activated carbon.[2] One to several days later, simazine wettable powder was applied at rates varying from 1 to 6 lbs. of active ingredient per acre. Granular simazine was included at a rate of 3 lbs. of active ingredient per acre in two comparisons.

The crops tested were strawberry (variety Jersey Belle), cabbage (variety Danish Ballhead), tomato (variety Rutgers), and rooted cuttings of privet (Ligustrum, variety Amur), Forsythia intermedia (variety Lynnewood Gold) and Euonymus sarcoxie. Injury was evaluated by visual ratings, runner counts in strawberries, clipping weights in the rooted cuttings, and by weighing whole plants of cabbage and tomato.

Weed control was satisfactory for 2 months with simazine at 1 1/2 lbs. per acre. Higher rates controlled weeds for longer periods.

The degree of protection afforded by the carbon root dips varied greatly with the crop and the rate of simazine applied. The carbon treatment was most effective in those plots where the undipped plants were only moderately injured by simazine. In general, granular simazine at 3 lbs. per acre caused less injury than simazine wettable powder at 1 1/2 lbs. per acre.

Undipped strawberry plants were severely injured or killed by simazine at 2 to 3 lbs. per acre, while carbon-dipped plants showed no injury and produced runners equal to or exceeding control plants.

Growth of undipped cabbage was reduced 28% by simazine at 1 1/2 lbs. per acre, while growth of carbon-dipped cabbage was reduced only 12%.

Tomato plants dipped in carbon were not protected from severe injury or growth reduction by simazine wettable powder. Tomato plants were slightly more tolerant of granular simazine

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at 3 lbs. per acre, which reduced growth of undipped plants 56% and carbon-dipped plants 44% compared with control plants.

Injury from simazine was greatest in privet and about equal in forsythia and euonymus. Root dips of carbon protected privet and forsythia but not euonymus against low rates of simazine.

These experiments demonstrate that activated carbon can improve selectivity of a strongly adsorbed herbicide in certain transplanted crops of marginal tolerance.

MINIMUM-DRIFT VISCOUS HERBICIDE SPRAYS FOR HELICOPTER APPLICATION TO WOODY GROWTH

J.W. Suggitt and J.E.F. Winter[1]

Helicopter application of herbicides to control undesirable woody regrowth on remote northern transmission-line rights of way has been a standard Ontario Hydro maintenance practice since 1956. Of approximately 40,000 acres of brush now sprayed annually, to date the acreage treated by helicopter reached a high point of 6300 acres in 1961. In the past, the most serious restriction on aircraft spraying was unsuitable weather, almost dead-calm conditions being required to avoid unacceptable spray-droplet drift. With aircraft spraying extended to lines with high steel towers, drift control became more difficult. In order that wind conditions at any time and location might be ascertained, a convenient method was developed/1/ of measuring the speed and direction of light wind at various altitudes. Despite such technical help, mainly because of the drift problem the aircraft application program began to be curtailed, to about 3300 acres in 1963. With the recent development of viscous sprays and suitable application procedures, as described in this article, the trend is now expected to be reversed.

Early aircraft sprays were based on 2,4-D and 2,4,5-T ester herbicides which killed susceptible deciduous regrowth. Later, the control of coniferous species, particularly such herbicide-tolerant species as black spruce, balsam and cedar, became increasingly essential. As potent chemicals which kill coniferous species were developed and became available/2,3/ Ontario Hydro was faced with a growing need to ensure that drift control would be within the requirements of Department of Lands and Forests' regulations. Since in winds of more than 3 miles per hour, gusts would carry the helicopter spray far from the right of way, helicopter flight times were severely limited, with ground and flight crews experiencing costly delays. As a consequence, the unit cost of aerial spraying, at first considerably below that of ground spraying, increased each year until 1963, with the cost advantage over ground spraying tending to become progressively less.

Factors Involved in Spray Drift

In 1962, a study was begun of means for producing herbicidal-spray droplets of a size that would drift least during application

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but yet provide the required leaf coverage for adequate vegetation control. The factors causing spray drift during aircraft application were also examined to determine whether the physical properties of spray droplets could be modified usefully.

Effective aircraft spraying depends on uniform spray coverage in terms of droplets per unit leaf area, as well as on the plant toxicity of the herbicide used. Ideally, all spray particles should settle on the plant foliage and should penetrate to understory or deep foliage. Since present aircraft spray equipment cannot produce droplets of uniform size, a median droplet size - an index of the relative fineness or coarseness of the spray - must be so chosen as to obtain the desired spray coverage. If the spray droplets are assumed to be uniform in size and can be distributed uniformly with no loss due either to evaporation or to wind drift, the coverage that can be expected on a flat surface with an application rate of 4 gallons per acre/4/, is shown in the accompanying Table. Since losses due to wind drift and water evaporation are inevitable, the desirable median droplet size required for Ontario Hydro aircraft spraying was set at 300 to 500 microns.

Droplet Coverage on a Flat Surface For An Application Rate of 4 Gallons per Acre

Diameter of Spray Droplets (microns)	Number per Square Inch	Distance Between Droplets, (inches)	Description of Falling Spray
1000	4.6	0.47	Moderate rain
500	37.0	0.16	Light rain
200	570.0	0.043	Drizzle
100	4600.0	0.015	Mist

With the solubility of herbicidal chemicals taken into account and the spray fluid required to penetrate into brush foliage of 6- to 10-foot height, for the proposed flight heights an application rate of 8 to 12 gallons per acre was necessary. With this rate and the most useful median droplet size both established, means of stabilizing the spray droplets formed were studied and application equipment was appraised.

The extent of drift of any spray solution during aircraft application depends on a number of factors, including spray-solution viscosity and density; spray pressure and nozzle size; flight height and aircraft speed; wind velocity and direction; relative humidity; and near-ground and higher-air temperatures. With these factors involved, the most practical approach to minimizing spray drift consisted of two steps: formation of spray

droplets of sufficient viscosity to inhibit break-up and to retard water evaporation, with less spray "fines" therefore resulting; and use of spray-dispersal equipment with large-size nozzles or orifices that would produce suitably sized droplets at lower spray pressures than otherwise.

Evolution of Viscous Sprays

Since the advent of crop spraying with aircraft, various methods of forming high-viscosity low-drift sprays have been promoted by agricultural chemical manufacturers. One of the earliest methods was the formation of water-in-oil invert emulsions. If properly shear-mixed, these produce a "mayonnaise"-consistency spray which adheres well to both wet and dry foliage and is slow drying. Sprays of invert emulsions do not drift as much as earlier sprays, and with oil as the major diluent, provide desirable leaf contact and phytotoxic effects due to the petroleum carrier. However, in field work during 1960 and 1961, with an invert emulsion formulation, despite proper shear during mixing the mixtures obtained were at times either too thin or too heavy because of the shear sensitivity of such sprays. Generally, spray of this type was deemed unsatisfactory for Ontario Hydro use, because of field handling problems, poor woody-growth control obtained, and invert-emulsion sensitivity to sodium trichloroacetate (TCA) added to control conifers.

Recently one manufacturer has promoted particulate sprays intended to allow little herbicide drift. Small particles of a water-swellable polymer, dispersed in an aqueous herbicide solution from which they imbibe liquid, well to some limited final size determined by the polymer used. With the addition of particles in sufficient quantity, essentially all the herbicide solution is taken up, with formation of a very thick, coarse granular liquid much like tapioca. On being applied with conventional spray equipment, the individual swollen particles largely separate to form a "particulate" spray of a uniform size, which drifts very little. Although these sprays consist of particles rather than liquid droplets, apparently no loss of herbicidal efficacy results. Because the present material cost is high and field experience is lacking, appraisal of this new system is difficult. The approach is probably the best yet available, however, for providing uniformly sized spray particles with a minimum proportion of spray fines.

During 1962, methods were studied of simultaneous spray application of 2,4-D and 2,4,5-T ester herbicides with TCA, both to coniferous and to deciduous woody plants. Oil-based herbicide emulsions do not form stable mixtures with TCA solutions; even with the best emulsifiers and thorough mixing the heavier TCA component rapidly separates to form a two-phase solution unsuitable for helicopter spraying. Hydroxyethylcellulose, however, in low concentration, was found to stabilize such spray mixtures; sprays

thus stabilized were applied successfully in northern Ontario during 1962.

During the spring of 1963, other chemically thickened herbicide spray solutions designed for minimum drift during application were studied. Various commercial products including colloidal clays, alginates, metallic soaps and substituted cellulose derivatives, intended to increase the viscosity of aqueous solutions, were checked in the laboratory. The most effective, a high-viscosity hydroxyethylcellulose, satisfactorily stabilized TCA and 2,4-D/2,4,5-T ester herbicide emulsions for a period of at least 100 hours.

The viscosity of solutions thickened with hydroxyethylcellulose depends on the amount added to a given volume of solution. Viscosity values given by a No. 4 Ford cup (ASTM Method D1200-48) proved convenient for correlating with degree of drift reduction and over-all handling properties. Viscosities of about 130 to 150 seconds provide satisfactory droplet cohesion and good thickened herbicide flow through appropriate application equipment. Such viscosities were obtained economically with addition of approximately 0.75 per cent of thickener, by weight.

The cellulose derivative finally chosen was of low density, easy to transport, in good supply, and suitable for field-mixing procedures. The most suitable mixing order of components for batch production of the viscous spray, the time required to reach maximum viscosity, gel stability, and the effects of water hardness and temperature, were all determined. Water conditions are important because aircraft spray mixtures used in northern Ontario are normally made up with surface waters ranging from 33F to 45F in temperature.

Application Practices and Equipment

Parallel studies were made of spray application equipment to determine the effects of spray-boom length, nozzle-placement patterns and aperture sizes, and of operating practices such as spraying pressures, equipment and pump delivery rates. Studies to determine the proper minimum height and operating speeds for the helicopter were also conducted. Field trials were first simulated in an 80-foot-high hut where droplet sizes were correlated with solution viscosities of the thickened sprays and distribution patterns were determined for spray that had fallen about 75 feet under static air conditions. Later a spray-boom-equipped helicopter flying in cross-winds of various speeds and at 70- and 140-foot heights, applied dyed viscous herbicide solutions over paper tapes to provide data on droplet distributions under field conditions and for final equipment calibrations. Based on the findings, field operating instructions were drafted.

At the outset of spraying operations in 1956 the helicopter fleet consisted entirely of Bell D1 helicopters equipped with Franklin engines. These machines have gr dually been replaced with nine Bell 47G2 and 47G2A models equipped with Lycoming engines. Earlier both a gas-turbine-powered French Alouett II and a Sikorsky S55 were used. A Sikorsky S58 required so far entirely on line construction will be used for aircraft spraying in the future.

During each spray flight the quantity of viscous spray carried is from 40 to 60 gallons. Throughout the development of aircraft spraying techniques for Ontario Hydro many equipment modifications have been made, including those indicated below.

The relative ease of spray-droplet formation is one of the critical factors affecting the suitability of viscous solutions for herbicide sprays. With invert-emulsion spray solutions tested during 1961 at viscosities high enough to avoid formation of too large a proportion of small droplets in the spray, the desirable hollow-cone spray pattern could not be produced satisfactorily. With hydroxyethylcellulose-thickened sprays, however, at viscosities to 190 seconds the hollow-cone configuration is comparable with that obtained with water from diaphram teeject nozzles. Nozzle output at 35-psi spraying pressure was about the same as for water, provided that the orifice diameter was greater than 1/8 inch. To obtain suitable spray-nozzle patterns and the required viscous-spray delivery rates of 36 gallons per minute, a 10/64-inch diameter orifice was required. The nozzle strainers and atomizers were removed to avoid excessive nozzle turbulence and to prevent the formation of fine droplets. To obtain a spray application rate of 12 gallons per acre at available pump capacities, 24 nozzles were evenly spaced along the spray boom.

In previous years, the Bell D1 helicopters with their Franklin engines could be fitted with power take-off pumps which were suitable for boom spraying operations. Replacement of the Franklin engines with Lycomings created a problem of inadequate pumping capacity. Close-coupled electric motor pumps used in pairs on the Lycoming-equipped G1 models were unsatisfactory, for with use both the flow rate and efficiency of the electric motor pumps diminished. Subsequently, a pump manufacturer in Toronto developed an efficient power take-off pump for the Lycoming engines, to Ontario Hydro specifications. These pumps have since been used continuously with flow rates of up to 50 gallons per minute and with almost no maintenance.

Viscous Spray Materials and Mixtures, and Field Batching

In areas where only deciduous species required herbicide treatment, a thickened spray formulation of 2,4-D and 2,4,5-T as a 1:1 mixture of low-volatile esters was applied as 4 pounds of

the acid equivalent per acre in 7 gallons of spray. Areas in which conifers such as balsam fir and black spruce predominate, were treated with a viscous spray mixture at similar rate of 2,4-D and 2,4,5-T, and with TCA at 25-lb acid equivalent in 12 gallons of spray. The TCA formulation used contained a corrosion inhibitor.

The viscous spray mixture was generally made up in 500- or 1000-gallon lots. For the final spray mixture about 70 to 75 pounds of high-viscosity hydroxyethylcellulose was added for each 1000 gallons of the other materials in the tank and mechanically mixed or circulated with a high-pressure centrifugal pump until the thickening action was complete. During the season's operations, often under most difficult conditions, ground crews were able consistently to produce the required volumes of the thickened spray in 1000-gallon batches, from the basic materials and local surface water. In the small quantities required, the thickening agent was inexpensive, the cost amounting to only 75 cents per acre.

To obtain a herbicide solution of uniform viscosity, the hydroxyethylcellulose must be completely wetted by and uniformly mixed in the solution. For small volumes the thickening powder can be stirred into the herbicide ester concentrate and the mixture then poured slowly into the water while being agitated. With large-volume batches of 100 gallons or more an efficient method is use of an eductor in combination with a high-pressure centrifugal pump to disperse the thickening agent rapidly. In the eductor - a mixing device that operates on the jet aspirator principle - the powdered hydroxyethylcellulose is drawn into water flowing at high velocity through a constriction. Because of the extreme turbulence resulting from the high velocity, the grains of powder are separated and dispersed, and each is thoroughly soaked. With eductor distribution of the thickening agent, consistency increase is rapid, and with adequate pumps a 1000-gallon batch of viscous spray can in 20 minutes be prepared to spraying viscosity. If mixing is not done properly, viscosity agents tend to lump or cluster on contact with water. Such clusters may become surrounded by a gelatinous coating which slows complete solution and in some cases can clog spray nozzles or jam mixing equipment. If mixed to uniform consistency the thickened spray mixtures can stand for extended periods without need for agitation before use.

Strategy of Spray Operations

The aircraft spray season for northern Ontario extends from early June to mid-August. In the earlier years, operations were restricted to periods of winds of very low speeds in order to minimize drift. Maximum use must be made of all periods of suitable weather, which usually are limited to the early morning and early evening hours. With viscous herbicide solutions available and greater control possible over droplet drift, spraying operations can be continued in light winds, sometimes even into midday.

Ideally, bases are located at 8- to 10-mile intervals along the line. In the more remote areas where no roads exist, all supplies and ground crew must be flown into base camps immediately adjacent to the lines. Small areas must sometimes be cleared for helicopter landing sites.

Obviously a well-organized supply system is necessary for servicing each unit of one to four helicopters and for recharging the spray tanks quickly. Where the terrain permits, each helicopter is supplied from a 2000-gallon tank truck or mixing tank in which the viscous spray is prepared. The tankers and mixing equipment are moved from base to base as the work progresses. In the more isolated locations, the viscous spray is mixed in drums and transferred to the aircraft with a high-volume centrifugal pump. From recent experience a pair of helicopters operating in conjunction is deemed to be the best arrangement.

During 1963 and 1964 spraying with thickened herbicide, the flying speed for the Bell helicopters was carefully held to 30 mph. Spray-load delivery required about two minutes, with approximately four acres sprayed. Averaging four flights per hour, each machine can therefore spray about 16 acres per hour.

Experience with Field Application of Viscous Sprays

Right-of-way helicopter applications of viscous sprays were begun in early June, 1963, to mixed deciduous and coniferous brush along the 100-foot right of way of a wood-pole line near Minaki. Two helicopters were flown, one one each side of the line, at 110-foot heights in ground winds of speeds of up to 7 mph. Each helicopter laid down a sharply defined 50-foot spray swath. Paper tapes stretched across the right of way indicated that the droplet pattern was essentially uniform, tailing off for only 4 to 5 feet at the swath edge in 6-mph cross-winds. With spray mixtures of viscosities from 120 to 140 seconds, unless weather was unfavourable spray application for the day was begun at 6:00 am and was continued until wind speeds reached 7 mph. Usually by this time 100 acres or more of right of way was sprayed.

With experience the ground and aircraft crews became increasingly proficient, and hence the acreage sprayed per day tended to become progressively greater. During one day, with application conditions ideal and ground winds never higher than the 8-mph maximum allowed, between 4000 and 5000 gallons of viscous spray was applied. Three pilots flying two helicopters from dawn until dusk made 40 flights with each machine, spraying in total about 340 acres.

Of some minor field problems that arose during the first year of use of viscous spray, the main problem was in methods of mixing. Prompted by this problem, improvements in field mixing

techniques were developed during the past winter season. In further laboratory studies of other possible thickening products, more economical commercial materials were found that are effective at lower concentrations, with the properties of more rapid dispersion and greater viscosity stability. Also the design was completed of an improved eductor for more rapid mixing of the hydroxyethylcellulose and the spray solution, and which will prevent lumping during large-batch mixing. The thickening powder can be sucked into the mixing tank in less than 1 minute and the spray solution readied for use within 20 minutes. The development of an improved wind-direction and -velocity measurement procedure designed for wind speeds of up to 10 to 12 mph has been studied. For brush spraying along ehv tower lines, the suitability of spray viscosities of 190 seconds for 160-foot aircraft heights was appraised.

Efficacy and Economics of Viscous-spray Applications

Examination of the brush foliage along the sprayed right of way confirmed that viscous-spray distribution and understory penetration of material were both very good. With the spray forming large spray droplets in a consistent pattern, little or no drift was observed in winds of up to 6 mph. The thickening agent effectively prevented evaporation of water from the spray droplets, which remained relatively heavy with little tendency to drift.

In addition to having better wind-drift characteristics than conventional herbicide solutions, the viscous herbicide has other physical characteristics which are advantageous in the control of woody growth. Because of its viscosity, it adheres better to leaves and stems. On striking a leaf the spray adheres, instead of bouncing or rolling off. For the same reason the spray adheres to dew or rain-wet leaves, and does not wash off foliage in a light rain following application. Because of the slower evaporation of water from the herbicide droplets, the herbicide activity in the plant leaves is prolonged. Generally, adequate coverage of all vegetation requiring treatment was obtained at the recommended application rates.

The effectiveness of the herbicides applied as viscous sprays in 1963 were appraised in 1964 after the pattern and extent of woody growth recovery had become established. Forestry personnel reported that spray coverage across the right-of-way, as shown by herbicide-affected woody plants, was better than that obtained in any previous aircraft spraying operation. Woody growth was controlled up to the wooded edge of the right-of-way with little indication of drift damage. The vertical coverage of spray on the brush had been good and observations of the brownout a month after spray application had indicated complete and uniform coverage. The 1964 observations also indicated that the kill of woody growth

was as effective as the most successful earlier aircraft applications of conventional sprays. By permitting aircraft spray applications to be made during a high proportion of the available flying weather, the 1963 program for 3300 acres was completed by July 21, primarily during the period of greatest plant susceptibility. The cost of aircraft spraying during the 1963 operations averaged about $23.50 per acre, and in one region the saving as compared with the previous year's cost was $8.90 per acre. In 1964 an aerial spraying program for 4148 acres was completed by July 28 with comparable savings.

Conclusion

In co-operation with the Forestry Department, the use was successfully developed for Ontario Hydro, of viscous herbicide mixtures, applied from spray-boom-equipped helicopters, for the control of woody growth in transmission-line right-of-way. After two years experience, excellent results have been obtained in largely avoiding spray drift, even with cross winds to 7 mph, and in providing good foliage coverage and subsequent kill to the right-of-way edges at costs substantially less than in previous years. Present observations indicate that droplet size and helicopter spray-boom distribution patterns are the principal factors influencing the effectiveness of the thickened spray, especially against more resistant understory and coniferous species.

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THE PHYSICAL PROPERTIES OF VISCOUS SPRAYS FOR REDUCTION OF HERBICIDE DRIFT

J.W. Suggitt[1]

Different approaches to the problem of reducing spray drift have earlier been reported before this conference. In 1960, J.H. Kirch/1/ described the work of one chemical manufacturer in utilizing invert emulsions for right-of-way growth control in the aerial application of ester herbicides. The physical properties of herbicidal invert emulsions were discussed by Wade Van Valkenburg/2/ in 1962, and in 1963 K.G. Seymour/3/ presented information on particulate sprays as a new method of reducing spray drift.

Despite these useful procedures, certain limitations inherent with invert emulsions and particulate polymer mixtures became apparent during early work by the Ontario Hydro on methods of drift reduction. The proprietary nature of the formulations, difficulties of field handling, formulation sensitivity to sodium TCA used for conifer control, and the considerable cost of such products, prompted an investigation of commercially available water thickening agents which might provide suitable minimum-drift viscous spray mixtures with good field handling and application properties. The purpose of this paper is to present information on a class of non-proprietary products which will economically convert water-based herbicide solutions or emulsions into viscous formulations designed to reduce spray drift.

Development work performed during 1962 studied various materials available commercially as water thickeners and which are extensively used in the latex paint and adhesives industires. Colloidal clays, alginates, acrylates, vinyl ethers and substituted cellulose derivatives were screened in the laboratory. The most effective was a high-viscosity grade of a water-soluble cellulose polymer, hydroxyethylcellulose (HEC), which satisfactorily stabilized sodium trichloroacetate (TCA) and ester herbicide mixtures used in aircraft spraying for a period of 100 hours. Further, the hydroxyethylcellulose met the stiff requirements for a suitable thickener laid down by the Ontario Hydro Forestry Group. It was easily handled in the field, mixed readily to thicken any herbicide formulation or combination of herbicides, formed the wide range of viscosities required with ground and aircraft spraying mixtures, only small amounts were required in each spray batch, the material was non-proprietary and available from several sources, of low density, easy to transport, in good supply and of low cost.

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The viscous herbicide mixtures developed were initially intended to reduce spray drifting during helicopter applications to woody growth, but recent work has shown that thickened sprays can effectively be applied from roadside boom-jet sprayers to reduce hydraulic spray drift, and to reduce fine fog formation with most mist-blower equipment used for spot spraying.

Viscosity of Thickened Sprays

The viscosity of spray mixtures thickened with hydroxyethylcellulose varies with the amount added to the solution, with the concentration of ester herbicides, and with the presence of dissolved salts, such as TCA. Viscosity values given by a No 4 Ford cup (ASTM Method D1200-48) proved convenient for correlating with degree of drift reduction and over-all handling properties. Ford cup viscosity is measured by determining the time in seconds for a given quantity of liquid to flow through an orifice at the bottom of a cup. Field personnel quickly master this method of viscosity measurement, the equipment is rugged and inexpensive and viscosity data is obtained within one or two minutes. For aerial application, viscosities of 130-150 seconds, obtained by the addition of approximately 0.75 per cent of thickener, provide satisfactory droplet cohesion and good thickened herbicide flow through application equipment. Roadside or right-of-way spraying generally utilizes sprays thickened to 18-25 second viscosities, or higher for greater drift reduction. Mist-blower equipment requires viscosities of 25-35 seconds to reduce the formation of fine droplets. Such viscosities require only 0.2 - 0.3 per cent by weight of HEC (Figure 1), based on the total weight of the spray mixture.

A proper mixing order of the herbicide and HEC is most important to obtain stable viscous solutions in a reasonable preparation time. The initial addition of emulsified ester herbicides to the water with later addition of the HEC can slow the thickening rate beyond practical limits (Figure 2). Field procedure is to first thicken the water, or water containing TCA, with the HEC and then, after the thickening reaction has begun, to add the required ester or fuel oil.

The slow thickening action of HEC, requiring 20-25 minutes to form usable spray mixtures utilizing an eductor or mechanical mixing, is a present field limitation to the greater use of thickened sprays. The time required for batch preparation must be carefully programmed otherwise costly spray crew time is lost. This factor has stimulated further evaluation of other types of thickening agents and chemical studies of methods of accelerating HEC gel formation. One useful approach is the addition of ethylene or propylene glycol as a water-miscible HEC prewetting agent. The resultant acceleration of the thickening rate is also shown in Figure 2. Subsequently, a glycol-HEC solution was developed for the field mixing of small batches of two to ten gallons of thickened spray for use in awkward or remote areas where only

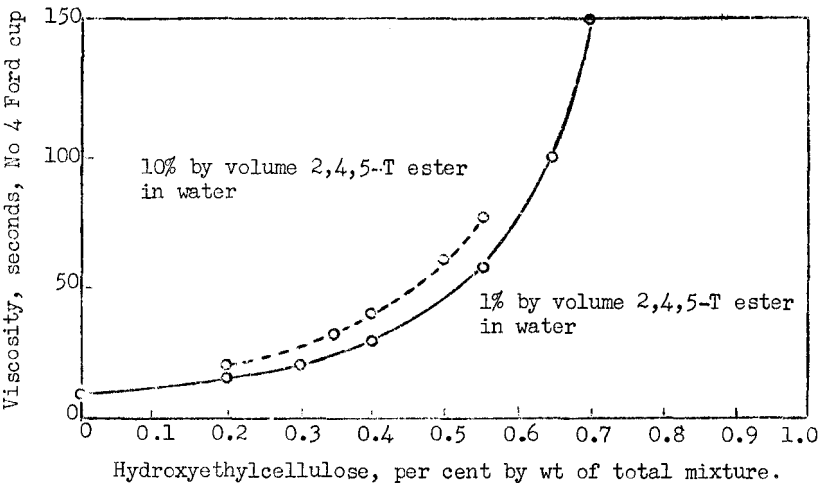

FIGURE 1

HERBICIDE VISCOSITY VS THICKENER CONCENTRATION

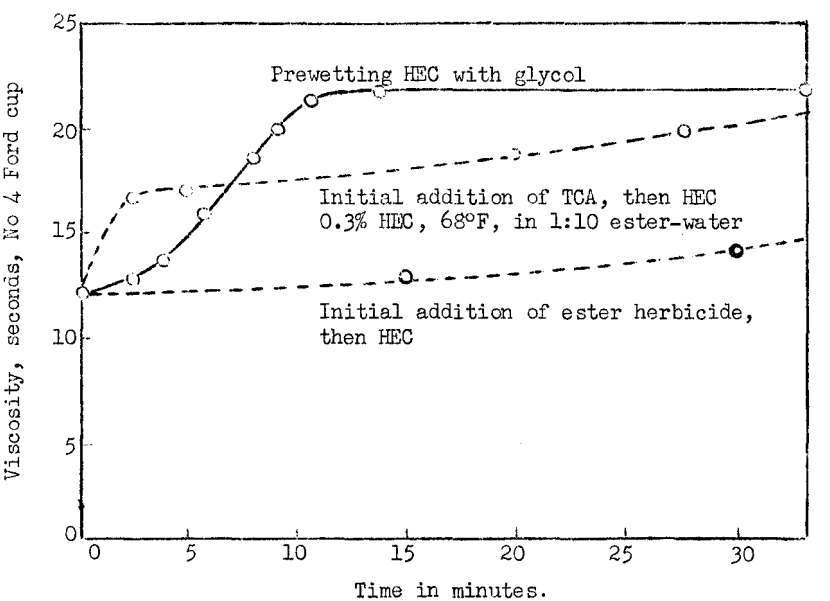

FIGURE 2

THICKENING RATE AND MIXING ORDER

hand paddling of the mixture is possible. Thickened herbicides intended to reduce fog generation with back-pack mist-blower equipment can readily be made with about eight minutes stirring. An additive solution was made for field use such that one gallon of thickening agent would rapidly thicken 25 gallons of spray mixture to the proper viscosity.

Characteristics of Thickened Spray Mixtures

No matter how well programmed a spraying operation, batches of thickened herbicides must often stand in the spray tank because of approaching wet weather, equipment breakdowns, or the end of a working period. Batches of thickened spray may stand over a weekend or, in aircraft spraying operations, for a week or longer. The viscosity of HEC thickened sprays will decrease while the mixture stands, the amount of viscosity loss depending mainly on the initial viscosity. Very high viscosity spray mixtures, as required for aircraft applications, exhibit a marked decrease in viscosity in 24-48 hours due to anzymes present in natural waters which attack and degrade the cellulose thickener. With low-to-intermediate viscosity spray mixtures, as generally used, the decrease is barely perceptible and such thickened spray mixtures maintain adequate viscosities on standing, as shown in Figure 3.

Water available for use during field spray mixing operations can vary considerably in water hardness. Surface run-off in some areas is a very soft water, whereas well or river waters can contain considerable quantities of hard water salts. In the presence of herbicide, water hardness was found to have little effect on spray mixture viscosity (Table I).

The effect of temperatures on spray solution viscosity at a given thickener concentration is much more pronounced. During aircraft spraying operations in Northern Ontario, spray mixtures in the early morning may have temperatures of 40-45 F with very high viscosities, and by late afternoon during July, available surface waters may have warmed to 70-75 F resulting in a greatly decreased viscosity (Figure 4). Field crews must therefore determine spray mixture water temperatures and adjust thickener additions to maintain recommended spraying viscosities.

Field Mixing of Viscous Sprays

Thickened sprays have been made utilizing a variety of herbicides. In areas where only deciduous species required herbicide treatment, a thickened spray formulation of 1:1 of 2,4-D and 2,4,5-T has been applied. Where conifers are a problem viscous spray mixtures of 2,4-D/2,4,5-T and TCA are utilized. Water solutions or mixtures of Tordon, simazine, atrazine and other herbicides, have successfully been thickened.

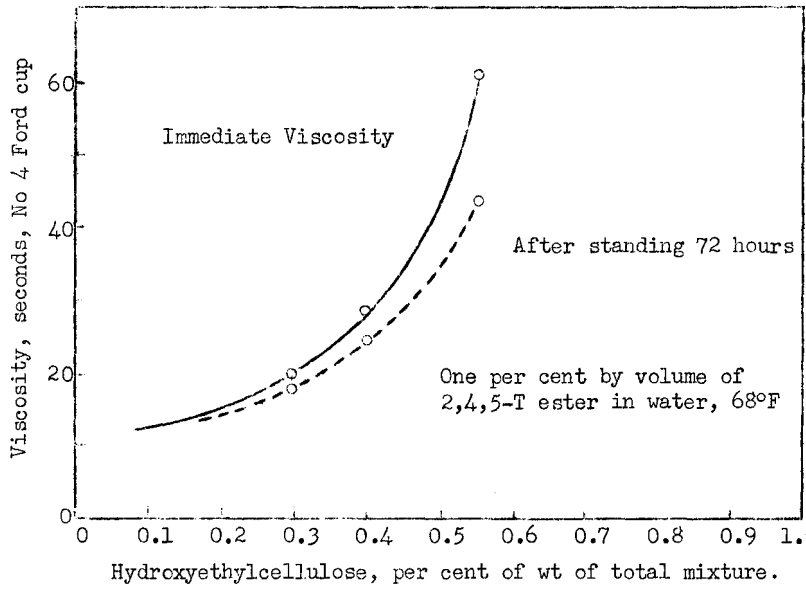

FIGURE 3

VISCOSITY STABILITY OF THICKENED HERBICIDE MIXTURE

TABLE 1

EFFECT OF WATER HARDNESS ON THE
VISCOSITY OF THICKENED HERBICIDE

Water Hardness grains per us gal	Viscosity, seconds No 4 Ford cup
0.	100
2.	125
7.7	133
19.8	140

For 0.65 per cent hydroxyethylcellulose with 2,4,5-T ester and TCA, 68°F.

To obtain a herbicide solution of uniform viscosity, the HEC must be completely wetted by and uniformly mixed in the solution. Proper mixing sequences must be followed for rapid thickening. With large-volume batches of 100 gallons or more of high-viscosity sprays, the most efficient method is the use of an eductor in combination with a high-pressure centrifugal pump to rapidly disperse the thickening agent. Mechanical agitation is usually sufficient and reliable with low-viscosity viscous sprays made in large spray or nurse tanks. Thorough agitation in the tank is necessary during the addition of the HEC regardless of the method employed. Adequate thickening generally occurs in about 20 minutes. If mixed to uniform consistency the thickened spray mixtures can stand for extended periods without need for agitation before use.

Viscous Spray Characteristics and Drift Reduction

With the viscosity increase that is obtained with HEC thickened herbicide sprays come valuable features such as slower evaporation of the water from spray droplets, better adhesion of the spray to dry and wet foliage, and a considerable spray drift reduction. However, the viscosity increase also adversely affects the spreading of spray solution on leaf surfaces. As shown in Figure 5, the spread can be reduced to about 40 per cent of what would occur were there no thickening agent present. It should not be concluded from this data that viscous sprays inhibit herbicide translocation. Quite the contrary seems to be true. The addition of thickener does not change the surface tension or interfacial tension properties of the spray, so that leaf wetting and cuticle penetration are still the same as before and probably improved due to increased herbicide contact time. The problem is one of getting the proper amount of the viscous mixture on the plant. With reduced spray spread, no dripping of spray solution from one leaf story to another, and reduction of bark wetting by the herbicide, spray coverage must be thorough.

Possible diminished herbicide effectiveness using viscous sprays was studied by comparing thickened and conventional sprays of 2,4,5-T and 2,4,5-T/TCA herbicides at lethal and sublethal concentrations of the herbicide. As far as can be observed from woody plant treatments in test plots, the viscous sprays do not appear to have decreased herbicidal properties and high-volume applications of thickened spray are not required in foliage and stem spraying. Lighter applications, of 35-60 gallons per acre, appear more appropriate. Data obtained from aerial application of thickened herbicides at 12 gallons per acre, as described in a companion paper/4/, has been very encouraging.

The amount of drift arising from the viscous sprays used in our operations decreased as the spray mixture viscosity increased. The most suitable viscosity is dependent on the application equipment being used, but in all cases our observations show a great reduction in spray drift using viscous sprays as compared to

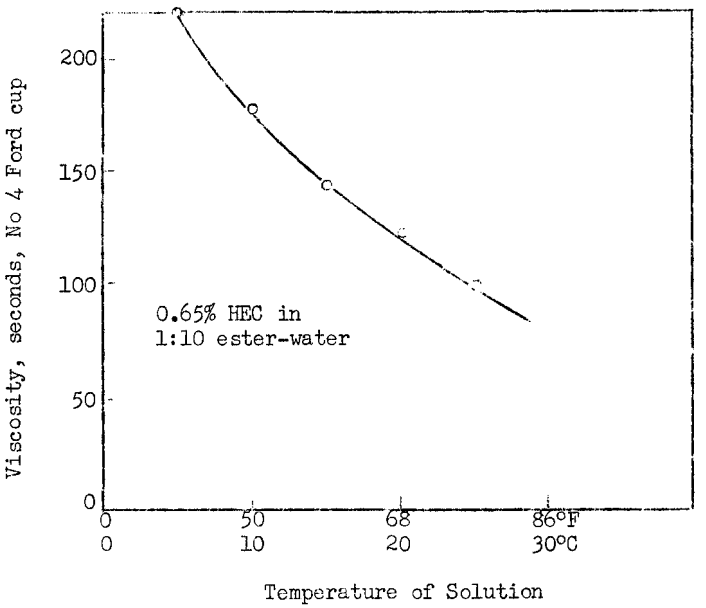

FIGURE 4

VISCOSITY-TEMPERATURE RELATIONSHIP

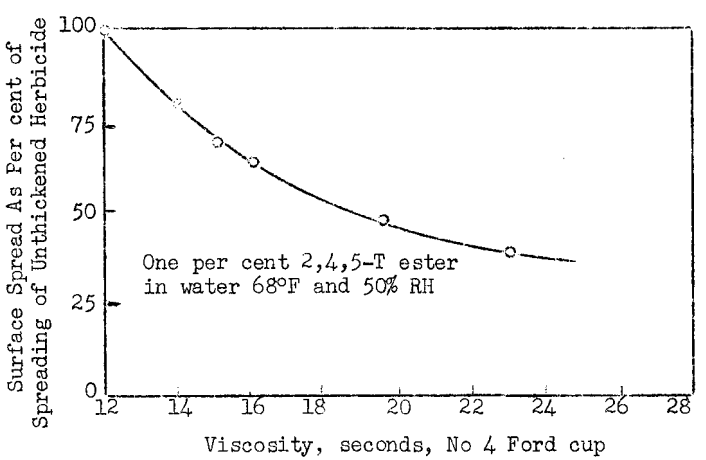

FIGURE 5

VISCOSITY-SURFACE SPREADING
OF THICKENED HERBICIDE

conventional unthickened sprays. Viscous sprays thus not only offer a very effective means for reducing drift, but by selection of the most suitable viscosity may offer a choice of the degree of drift reduction according to the type of spray operation and the drift hazard concerned. Although the formation of fine spray droplets is minimized by the use of viscous sprays, there are still some fine particles present in the pattern which can cause trouble if care and common sense are not used during applications.

Conclusion

A simple, adaptable method is presented of thickening herbicide mixtures with hydroxyethylcellulose to form viscous sprays with a reduced tendency to the formation of spray fines and herbicide drifting during application. Field production of thickened spray is rapid, mixtures are stable, unaffected by soluble salts, and can be made in an extended range of viscosities to meet application requirements using available commercial equipment. The amount of low-cost thickener required is low, generally being less than one-half per cent of the total spray mixture.

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4-amino-3,5,6 Trichloropicolinic Acid Pellets for Brush Control in the Northeastern United States

R. A. Schwartzbeck[1/]

Introduction

Chemical control of undesirable wood plants on both public and private utility rights-of-way has been an established practice for many years. Herbicides used as sprays in these programs have been mainly 2,4-D and 2,4,5-T. While these programs could be considered successful, it has been found that special control methods such as granules or pellets would be more practicable in certain situations.

Early experiments and commercial applications have shown the outstanding herbicidal activity of foliage sprays of Tordon® herbicide on many broadleaved herbaceous plants and on most woody plants. Chemically, this herbicide is 4-amino, 3,5,6-trichloropicolinic acid and is known universally by the Dow trademark Tordon. Laboratory results also showed Tordon herbicide to be readily absorbed by plant roots and thus a granular formulation was developed.

Exploratory testing with this herbicide by Dow research 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 as a soil application because of its activity at low concentrations and effectiveness on many species.

After the exploratory work was completed, field plots were established throughout North America to evaluate more fully under varying environmental conditions, specific dosage rates, effect of soil types, effect of rainfall, optimum application times and methods of application for treating the many species composing the brush problem on industrial rights-of-way.

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.

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Materials and Methods

Experimental sites were established 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.

Tordon 10K pellets containing 10% Tordon as the potassium salt incorporated in extruded clay pellets 5/32 inch diameter were distributed by hand in early spring to duplicate 5,000 sq. ft. plots, at rates of 3.0, 4.5, 6.0, 7.5 and 9.0 pounds acid equivalent per acre. Observations were made throughout the balance of that year and through the following year's growing season. In two locations applications were made periodically during the entire year. One of the experimental areas was established in cooperation with the Virginia Electric Power Company near Richmond, Virginia on a 200-foot transmission R/W. This line had been foliage sprayed three years before the experiment with a spray mixture of 2,4-D and 2,4,5-T at 2 pounds of each in 50 gallons of water per acre using a fixed nozzle. The loam A horizon was covered with a thin layer of organic matter with a clay loam B horizon. The soil was poorly drained in some depressions. Chemical and physical properties of this and other experimental site soils are given in Table I.

The major species recorded at the time of treatment ranged in height from 2 to 18 feet. They were as follows: red maple (Acer rubrum), white oak (Quercus alba), southern red oak (Quercus falcata), loblolly pine (Pinus taeda), shortleaf pine (Pinus echinata), persimmon (Diospyros virginiana), eastern red cedar (Juniperus virginiana), willow oak (Quercus phellos) and and several species of dewberries and briars.

Another experimental location was established in cooperation with the Potomac Edison Company near Hagerstown, Maryland, on a 250-foot transmission R/W. The plot area had never been treated chemically.

The thin layer of loam soil high in organic matter was underlain by rock.

Major species recorded at the time of treatment ranged in height from 5 to 25 feet. They were: northern red and white oak, sumac (Rhus glabra), sassafras (Sassafras albidum), basswood (Tilia americana), black locust (Robinia pseudoacacia), red maple, shagbark hickory (Carya ovata), smilax and briars.

TABLE I

Chemical and Physical Properties of Treated Soils

Location	Soil Type	pH	O.M. %	Sand %	Silt %	Clay %	Lbs. Available/A mg	P_2O_5	K_2O	Rainfall in Inches May - September Year of Treatment Compared to Normal
Richmond, Virginia	loam	5.1	2.3	68.0	23.6	7.4	55	11	84	-7.4
Hagerstown Maryland	loam	6.3	4.8	58.0	32.0	8.8	388	37	182	-3.2
Greensburg Pennsylvania	loam	4.9	3.1	48.2	30.4	20.4	35	13	56	-5.5
Buffalo New York	loam	7.4	4.6	54.2	23.0	22.8	101	39	148	+5.8
Auburn Maine	loam	5.4	4.6	64.4	27.8	7.8	92	150	174	-1.8

An experimental area was also established in cooperation with West Penn Power Company, Greensburg, Pennsylvania, on a 100-foot transmission R/W. This line had been foliage sprayed, with a mixture of 2,4-D and 2,4,5-T at 2 pounds each in 100 gallons of water, six years before the experiment was applied.

The loam soil which was in the Westmoreland series was level, well drained with a 1-inch surface layer of leaf litter and undecomposed organic matter.

Major species recorded at the time of treatment ranged in height from 3 to 25 feet and included: red maple, sassafras, wild cherry (Prunus serotina), quaking aspen (Populus tremuloides), cucumber tree (Magnolia acuminata), red and white oak, chestnut (Costanea dentata), dogwood (Cornus florida), hickory, black locust, wild apple, sumac, wild grape, blueberry and smilax.

An experiment was established in cooperation with Niagara Mohawk Power Company on a 75-foot distribution line at Buffalo, New York. This line had not been treated for the previous ten years.

The loam to clay loam soil was level and poorly drained.

Major species recorded ranged in height from 6 to 16 feet and were as follows: sumac, red and white oak, cherry, birch (Betula populifolia), alder (Alnus rubra), white ash, briars, smilax and teasel.

Experiments were made in cooperation with Central Maine Power Company, on a 150-foot transmission line near Auburn, Maine. This line has been basal stem sprayed three years prior to the test application using 16 pounds 2,4,5-T in 100 gallons of oil.

The loam soil was well drained with a 15 degree slope off of the right-of-way.

Major species were recorded at the time of treatment as follows: balsam fir (Abies balsamea), northern red oak, red maple, Balm of Gilead (Populus gileadensis), white pine (Pinus strobus), white cedar (Thuja occidentalis), grey birch (Betula populifolia), sumac, alder ground juniper (Juniperus sp.), wild cherry, larch (Larix laricia), high and low bush blueberries and sweet fern. Most of the species were 2 to 8 feet high at time of treatment.

Results and Discussion

Treating in the spring or early summer when plants were growing most rapidly was more effective than applications made during late summer, fall or winter in which case higher rates of application were required for satisfactory control of most species. Applications at time of bud-break, or just before, gave optimum results if accompanied by rainfall soon after treatment to carry the herbicide into the root zone. Maximum effectiveness of soil applications appear to be directly related to that time when plant roots are most actively absorbing water and nutrients from the soil.

Soil conditions influenced the plant response to Tordon. On sandy soils where leaching occurred, it was very important to apply the pellets in the spring when roots were actively growing to provide adequate control. As noted above, applications in the late summer, fall and winter were considerably less effective than spring treatment probably due to leaching of Tordon occurring in the fall and winter carrying the herbicide beyond the root zone area and thus making it unavailable for root absorption during periods of active growth. Similar results were noted on rocky, gravelly soil that presumably would also be very subject to leaching. Erratic results were sometimes observed in rocky areas. This may have been caused by the large rocks acting as a shield which would prevent the herbicide from coming into contact with the roots.

Moderate rainfall following the treatment appeared to be desirable to obtain maximum effectiveness. Conversely, with little or no rainfall limited plant response was observed.

Although the time of application, soil type, and rainfall affected the results obtained with soil treatments of Tordon, in general, excellent control of many problem brush species was obtained. Tordon at 6 to 8.5 lb./A. applied to the soil when brush was actively growing gave good control of almost all brush species common on industrial sites in the United States.

The pellets were most effective when evenly distributed over the entire root system of the plant. Broadcast applications over the rights-of-way, for example, proved the most effective method of distribution tested. Spot applications were applied by distributing the pellets evenly from the stem out to one foot beyond the extremity of the branches (crown or drip line). This method of treating was also effective and should be useful where sparse stands of brush are to be treated.

Injury to trees outside of the areas treated with Tordon was minor in these experiments. Trees with lateral roots growing into the area treated with Tordon often showed twisting of leaves and terminal growth on the side next to the treated areas. Complete kill of trees growing 10 to 20 feet from the edge of the treated area did occur in a few cases.

Applications of the pellets were made to sloping ground to assess the potential problem of lateral movement by sheet erosion. Applications on areas with a 15° to 45° slope followed by moderate rainfall showed no symptoms of herbicidal action on vegetation downgrade. However, when extremely heavy rainfall (2 to 5 inches) occurred immediately after treating, symptoms were visible on susceptible plantsdowngrade 50 to 75 feet apparently resulting from sheet erosion of the soil surface. On the soil with a duff layer it was noted that little or no lateral movement of Tordon occurred even though heavy rainfall occurred.

Since Tordon is a very effective herbicide even at low concentrations, experiments indicate that extreme care should be taken to avoid placing Tordon pellets directly in irrigation water or where subsequent movement to desirable broadleaved plants may occur.

The ground cover in areas treated with the pellets was changed following treatment. In areas where broadcast applications were made, grasses rapidly formed a dense sod and most broadleaved weeds were killed but some resistant shrubs survived. Treating in the early spring with high rates did reduce the population of some rhizomatous grasses such as Johnsongrass and quackgrass. In areas where spot applications were made, the plant communities outside of the areas actually treated were not altered and shrubs and broadleaved plants were not injured and in these areas most broadleaved plants were eliminated and a dense grass sod formed. Treated areas were less susceptible to soil erosion following treatment because of the excellent grass sod that developed.

Summary

Tordon is effective for the control of woody plants when applied to soil in the root zone. Pelleted formulations were easily applied by hand or mechanical equipment, either as broadcast applications or spot treatments. Both of these types of application made during spring or early summer were more effective than applications made during other seasons. Rainfall following treatment is needed to obtain maximum control.

Injury to trees growing outside the treated area has been minor. Foliage symptoms have been observed on some species growing near the treated area but complete kill of these trees has been unusual. Since Tordon is a highly efficient herbicide, care in application is needed to avoid injury to desirable plants.

Annual weeds, flowers and grasses soon become established after killing the brush and the second year following application practically covered the entire area.

TABLE II

Woody Plants Controlled by 80, 75 and 65 lb./A. of Tordon 10K Pellets

80 lb./A.	
Common Name	Scientific Name
Alder	Alnus spp.
Aspen	Populus spp.
Balsam Fir	Abies balsamea
Birch	Betula spp.
Button bush	Cephalanthus pubescens
White cedar	Thuja occidentalis
Cherry	Prunus spp.
Dogwood	Cornus spp.
Elderberry	Sambucus canadensis
Winged elm	Ulmus alata
Sweet gum	Liquidambar Styraciflua
Hemlock	Tsuga canadensis
Black Locust	Robinia Pseudo-Acacia
Honey locust	Gleditsia tricanthos
Maple	Acer spp.
Mesquite	Prosopis juliflora
Mulberry	Morus rubra
Pine	Pinus spp.
Redbud	Cercis canadensis
Wild rose	Rosa spp.
Sumac	Rhus spp.
Sweet bay	Magnolia virginiana
Willow	Salix spp.

Table II continued

75 lb./A.

Common Name	Scientific Name
Cedar	Juniperus spp.
Cypress	Taxodium spp.
American elm	Ulmus americana
Douglas fir	Pseudotsuga taxifolia
Gallberry	Ilex glabra
Hickory	Carya spp.
Larch	Larix laricina
Persimmon	Diospyros spp.
Tulip poplar	Liriodendron tulipifera
Sassafras	Sassafras albidum

85 lb./A.

Ash*	Fraxinus spp.
Black gum*	Nyssa sylvatica
Hawthorne	Crateagus spp.
Oak	Quercus spp.
Sourwood	Oxydendrum arboreum

* Retreatment may be necessary for satisfactory control.

A NOTE ON DAMAGE TO TOBACCO BY LATERAL MOVEMENT OF PICLORAM

Allan H. Kates[1]

Although herbicides have many benefits, they can create problems. Spray drift of herbicides to susceptible crops is of constant concern to all users. The possibility of lateral movement is also always of concern, but most herbicides present few hazards in this respect. This paper is a report of the lateral movement of picloram (4 amino-3, 5, 6-tichloropicolonic acid) from the area of application to a crop area.

Picloram has been tested and reported effective at relatively low rates for the control of many woody species (3). The problem of injury by spray drift of picloram on adjoining desirable species has been recognized. Through their roots, plants from adjoining areas have picked up the chemical from treated areas (2). Reports of lateral movement of picloram on the soil surface has been limited (4). In Virginia a limited acreage of tobacco was injured in 1964 by the lateral movement of picloram.

Field Observation

During the last week of May 1964, a large acreage of utility right-of-way in Virginia was treated with a combination of picloram at ½ lb. and 2,4-D at 2 lbs. in 50 gallons of water. In July most woody species on the right-of-way were dying. It appeared that good coverage had been accomplished with the ground sprayer, without drift to adjoining areas.

In July 1964, a number of farmers reported various degrees of malformed leaves on about 50 acres of tobacco. Most of these farmers were aware of the growth responses produced by phenoxy type of herbicides. The tobacco was exhibiting stem and leaf responses. On some leaves, there was an abnormal point developed at the leaf tip. This point varied between 1/4" and 3/4" long, and about 1/16" wide. On some of the leaves a darker area developed just back of this pointed tip. Many leaves developed various degrees of puckering and thickening of leaf tissue just back of the leaf margin. As this puckering and thickening increased, the leaf became cupped. This cupping was downward, with the upper surface of the leaf forming the outside of the cup. Terminal growth stopped on many plants and lateral shoots developed abnormally. On other plants, leaves developed only as thickened petioles, with only a ball of proliferated tissue in place of a blade.

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[1] Associate Weed Specialist, Virginia Agriculture Extension Service, Blacksburg, Virginia.

The degree of injury could ba associated with the amount and time of irrigation from certain sources. The tobacco has been transplanted between May 10 and 30. From June 1 to 29, only traces of rainfall were measured in the area. On June 29, 0.8" to 1.0" of rainfall occured in about 15 minutes. Most farmers with the abnormal tobacco started irrigation on July 1, and continued through July 9. Between July 9, and August 1, 10" to 13" of rainfall was recorded in this area. Injury was related to the amount of irrigation water applied. One farmer had used approximately 2 inches of water and about 75% of the leaves were severely cupped. There were portions of this irrigated field that the pipeline could not reach and in these areas the growth was normal. Some stunting of the irrigated tobacco could also be observed. Another farmer had used approximately 1", 1/2", and 1/3" of water on various parts of his tobacco acreage. About 40% of the leaves were cupped on the area with the heavier rate, whereas less than 10% of the terminal leaves were slightly cupped on areas receiving the lowest rate of water. Leaves of the tobacco were severely cupped in small areas where water had drained from the irrigation pipe.

Part of the watershed to these farm ponds or streams included the right-of-way treated with picloram. Distance between treated surface water drainage areas to irrigation pump intake varied between 1/8 and 2 1/2 miles.

In four fields, total of 13.2 acres, which received no irrigation, an odd pattern of injury occurred. There would be 2 to 10 plants in an area in which center leaves were severely cupped downward. Their terminal growth had stopped and leaves appeared as short projections. This injury was later associated with mule manure under the plants. Mules were used to cultivate this field. These mules had grazed in the treated areas under the power lines.

Field Applications of Picloram on Tobacco

Tobacco was found to be highly sensitive to picloram. The chemical was applied on August 31 to actively growing tobacco plants. They were about 2' tall with 5 and 6 leaves, 8" to 16" long. Two plants in each of 2 fields were treated with 10 cc of each of the following concentrations of picloram: 0.01, 0.1, 1.0, and 10.0 ppm. A pipette was used to distribute the solutions on the lower 4 or 5 leaves. There was no run off and none was applied to the terminal leaves.

Twenty-four hours later malformed terminal leaves were observed with the 10 ppm concentration. After 2 weeks the following growth symptoms were observed:

0.01 ppm - New leaves developed a slightly abnormal leaf tip. The leaf point was about 1/4" long and 1/16" wide.

0.1 ppm - New leaves had abnormal leaf tips as above with very slight indications of thickened cells and puckering of leaf margin just back of the tip.

1.0 ppm - All rapidly developing leaves above the treated area were cupped downward and stunted.

10.0 ppm - Terminal growth stopped, leaves developed as thickened petioles with proliferated tissue in place of a blade. Lateral shoots were starting to develope, indicating a stoppage of terminal growth.

Assuming 6000 to 7000 tobacco plants per acre, 10 cc of 10 ppm of picloram is equivalent to about 0.6 to 0.7 grams active ingredient per acre.

Bioassay for Picloram

Bioassay methods (1) for 4-amino-3, 5, 6-trichloropicolinic acid were used to determine its presence in soil and in mule manure samples obtained from the tobacco fields. Tobacco plants 3" to 4" tall were used as indicator plants. The standard solutions used were 0.005, 0.01, 0.1, 0.5, 1.0, and 0 ppm. These solutions were used at the rate of 100 cc to 1000 grams of quartz sand or soil. Soil from two fields with heavy damage and the mule manure sample developed definite symptoms similar to those caused by picloram. The top 1 to 3 leaves had pointed tips and were cupped slightly downward. Symptoms on the tobacco grown in the soil samples indicated less picloram than in the 100 cc of 0.005 standard solution. Very slight symptoms (1 leaf with abnormal tip) developed on the tobacco grown on soils from fields with medium amounts of injury. Tobacco grown in the mule manure samples (25 grams dry weight to 1000 grams of sand) developed symptoms similar to the standard solution of 100 cc of the 0.01 ppm in sand.

Conclusion

1. Injury occurred to tobacco, similar to that obtained by direct application, from the movement of picloram from a treated area through surface drainage to farm ponds and was applied through irrigation.

2. Picloram was also transferred to susceptible crops via livestock that had been grazing on areas treated with picloram.

3. Tobacco is highly sensitive to picloram.

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INHIBITION OF TREE GROWTH WITH VARIOUS CHEMICALS[1]

T. O. Evrard and W. E. Chappell[2]

Introduction

The two larger electric utilities in Virginia each spend between 3/4 and 1 million dollars per year on tree trimming, with an estimated 3 to 4 million dollars being spent state-wide by all utilities. In a city such as Roanoke, 3/4 of all street trees are trimmed once a year. Recent opposition to trimming has sprung up from garden clubs, homeowners, municipalities, etc.

In the summer of 1964 experiments were initiated on controlling tree growth with chemicals. All chemicals used except MH-30T and B-995-W50 have been used on a limited area but on a wide variety of species to test their phytotoxicity. B-995-W50 and MH-30T, because of their previous extensive usage, were applied as a semi-commercial operation in the city of Roanoke in cooperation with the city officials, Appalachian Power Company, Bartlett Tree Expert Company, and U. S. Rubber Company.

Materials and Methods

Treatments	Rate	Tree Species
1. CIPC W-50[3]	5000 ppm	Locust, Red Maple, Silver Maple, Sugar Maple, Norway Maple, Willow Oak, Pin Oak, Red and White Oak, Chinese & American Elm, Locust, Red Maple, Red and White Oaks.
2. IPC W-75[3]	"	
3. CIPC-MIK[3]	"	
4. BP-12 MIK[3]	"	
5. Cycocel[4]	"	
6. BP-12 Type H[3]	"	
7. Hadacidin 61-265[5]	"	
8. MH-30T[6]	4 lb/50 gal water	All trees above plus Tulip Poplar, Box Elder Maple, Sycamore, and Linden.
9. MH-30T + B-995-W50[6]	4 lb/50 gal water + 5000 ppm	
10. MH-30T + B-995-W50[6]	2 lb/50 gal water + 5000 ppm	
11. B-995-W50[6]	5000 ppm	

[1]Virginia Council of Highway Investigation and Research, U. S. Bureau of Public Roads, and Virginia Department of Highways, cooperators.

[2]Instructor and Professor of Plant Physiology, respectively, Virginia Polytechnic Institute, Blacksburg, Virginia.

[3]Chemicals supplied by Pittsburg Plate Glass Company.

All chemicals were sprayed to foliage runoff using either a knapsack sprayer or a hand boom attached to a pressurized tank (40 psi) mounted on a skyworker.

As shown above, a variety of tree species was used, their heights ranging from 3 feet to large mature city shade trees. Trimming dates on trees tested ranged from July, 1963, to 3 weeks prior to treatment. Some trees were not trimmed at all.

Results

Only two chemicals exhibited noticeable phytotoxicity in these experiments. Hadacidin at the rates used defoliated black locust and caused severe leaf burn on oak with less damage on maples. MH-30T caused some burning back of the tips of elms and maples. However, these effects were not severe and when viewed from the ground the reaction produced was not objectional.

In the city of Roanoke 150 large shade trees were sprayed with MH-30T and B-995-W50 with no adverse public sentiment expressed at the time of application or during the growing season.

The more promising chemicals tried were MH-30T, MH-30T + B-995-W50, CIPC W-50, BP-12 MIK and Cycocel.

These results are very preliminary and further testing is needed to establish proper rates, timing, application, and phyto-effects.

Our program will be expanded keeping in mind the following objectives:

1. Maintain shade and ornamental trees in a more uniform, natural, characteristic shape over a longer period of time with a minimum of manual trimming.

2. Chemical pruning would lessen the number of cuts and open wounds caused by today's tree trimming practices. These cuts are frequently left unpainted and subject to disease and insect invasion--a basis for much public resentment.

3. Reduce costs of utility maintenance, which, of course, the consumer pays for. A reduction in these costs would benefit a very large number of people.

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[4]Chemicals supplied by American Cyanamid Company.

[5]Chemicals supplied by Amchem Products, Inc.

[6]Chemicals supplied by Naugatuck Chemical Company.

INDUSTRIAL WEED CONTROL WITH AN EMULSIFIABLE CONCENTRATE OF 2,3,6-TRICHLOROBENZYLOXYPROPANOL, BROMACIL, 2-ETHYLHEXYL-2,4-DICHLOROPHENOXYACETATE

by

R. H. Cooper, V. W. Woestemeyer
R. F. Crawford, and J. T. Hallett[1]

MAINTAIN is a liquid emulsifiable concentrate containing 2 lbs. of 2,3,6-trichlorobenzyloxypropanol, 1 lb. of bromacil, and 0.2 lb. of 2,4-D acid equivalent per gallon. When diluted with water, MAINTAIN forms a stable emulsion that can be sprayed with conventional equipment.

Composition

Chemical Name: 2,3,6-Trichlorobenzyloxypropanol
2-Ethylhexyl ester of 2,4-D Acid
5-Bromo-3-s-butyl-6-methyluracil

Chemical and Physical Properties:

Typical Chemical Analysis:

Active Ingredients:

2,3,6-Trichlorobenzyloxypropanol (TRITAC) 21.30%
2-Ethylhexyl Ester of
2,4-Dichlorophenoxyacetic Acid 3.21%
(2,4-Dichlorophenoxyacetic Acid Equivalent 2.07%)
Bromacil (5-Bromo-3-sec-butyl-6-methyluracil. . . 10.37%

Inert Ingredients. 65.12%

Contains 2 lbs. of 2,3,6-trichlorobenzyloxypropanol, 0.2 lb. of 2,4-dichlorophenoxyacetic acid equivalent, and 1 lb. of bromacil per gallon.

Specific Gravity: 1.16 at 70° F.

Physical State: Brown liquid
Emulsifiable concentrate

[1] Agricultural Research & Development Department
U. S. Borax Research Corporation
412 Crescent Way
Anaheim, California 92803

MAINTAIN is a multipurpose herbicide useful in controlling a wide variety of plant species. MAINTAIN is an excellent herbicide for the control of grasses and annual broadleafs as well as deep-rooted perennial and vine species. Rapid initial action and a quick knockdown of existing broadleaf vegetation is obtained at application time. In addition, this formulation has excellent residual effects in the soil.

By varying the amount of concentrate used, MAINTAIN can be employed for general vegetation control on a wide variety of weed problems. Two to 4 gallons per acre are sufficient for maintenance control and annual weed situations. Four to 8 gallons per acre are necessary for initial application where weed growth is heavy or where hard-to-kill weeds, such as deep-rooted perennials or vines, are present

Annual Weeds - Rates	Illustrative Species
2 - 4 Gal. per acre	Cheat (*Bromus secalinus*) Fleabane, Annual (*Erigeron annuus*) Fleabane, Canada (*Erigeron canadensis*) Foxtail, (*Setaria* spp.) Kochia, (*Kochia scoparia*) Lambsquarters (*Chenopodium album*) Lettuce (*Lactuca* spp.) Mustard (*Brassica* spp.) Ragweed, Annual (*Ambrosia* spp.) Redroot Pigweed (*Amaranthus retroflexus*) Russian Thistle (*Salsola kali*) Sweet Clover (*Melilotus alba*)

Perennial Broadleafs - Rates	Illustrative Species
4 to 8 Gals/Acre	Bindweed, Field (*Convolvulus arvensis*) Bindweed, Hedge (*Convolvulus sepium*) Canada thistle (*Cirsium arvense*) Chicory (*Cichorium intybus*) Dandelion (*Taraxacum officinale*) Goldenrod (*Solidago* spp.) Honeysuckle (*Lonicera* spp.) Plantain (*Plantago* spp.) Ragweed, perennial (*Ambrosia psilostachya*) Toadflax, Yellow (*Linaria vulgaris*) Trumpet vine (*Campsis radicans*) Virginia creeper (*Parthenocissus* spp.) Wild strawberry (*Fragaria* spp.)

Another formulation of MAINTAIN known as MAINTAIN® 21 is available for areas having restrictions on the use of 2,4-D. The composition is identical to MAINTAIN, without the 2,4-D.

MAINTAIN gives best results when applied during the early growing season. However, due to its rapid initial action it can be used later in the season than many other herbicides and still obtain good control. Where herbaceous

perennial broadleafs constitute a part of the general vegetation, fall applications of MAINTAIN are also recommended.

As a general rule, heavy soils and rainfall areas above 30 inches require heavier applications of MAINTAIN than sandy soils and regions of lower annual precipitation.

MAINTAIN has been widely tested across the United States and was marketed in limited quantities in 1964.

Average Performance Data:

Vegetation Type	Per Cent Control	
	Rate/A.	Over-all
Annual Weeds	2 Gals.	77
	3 Gals.	87
	4 Gals.	96
Mixed Vegetation with Perennial Broadleafs	4 Gals.	40
	6 Gals.	75
	8 Gals.	87

INDUSTRIAL WEED CONTROL WITH A TRUE SOLUTION OF SODIUM METABORATE, SODIUM CHLORATE AND BROMACIL

by

R. H. Cooper, V. W. Woestemeyer,
R. F. Crawford, and J. T. Hallett[1]

HIBOR is a ready-to-spray liquid herbicide containing 70 pounds of sodium chlorate, 100 pounds of sodium metaborate and 3 pounds of bromacil per 100 gallons of solution.

Chemical Composition:

	Per Cent	Lbs/Gal
Sodium Metaborate, Anhydrous ($Na_2O \cdot B_2O_3$)	10.00	1.00
Sodium Chlorate ($NaClO_3$)	7.00	0.70
Bromacil	0.30	0.03

Physical State: A clear, colorless true solution

Specific Gravity: 1.179 at 20° C.

Pounds/Gallon 9.82

pH 11.80

HIBOR is a true solution that is adapted, particularly, to railroad weed control. It can be sprayed with any conventional spray equipment.

By varying the volume of application it can be used for maintenance or for initial clean-up work. For maintenance treatment, 100 to 150 gallons per acre are usually sufficient, while 150 to 250 gallons per acre may be needed for the first application on previously untreated areas and where hard-to-kill species are present.

Annual Weeds - Rates	Illustrative Species
100 to 150 Gals./Acre	Crabgrass (*Digitaria* spp.) Fleabane, Canada (*Erigeron canadensis*) Foxtail (*Setaria* spp.) Lambsquarters (*Chenopodium album*) Mustard, wild (*Brassica* spp.) Oats, wild (*Avena fatua*) Ragweed, annual (*Ambrosia* spp.) Sunflower (*Helianthus* spp.)

[1] Agricultural Research & Development Department, U. S. Borax Research Corporation, 412 Crescent Way, Anaheim, California 92803

Perennial Vegetation - Rates	Illustrative Species
150 to 250 Gals./Acre	Carrot, wild (*Daucus carota*) Bermuda grass (*Cynodon dactylon*) Dandelion (*Taraxacum officinale*) Goldenrod (*Solidago* spp.) Johnson grass (*Sorghum halepense*) Ragweed, perennial (*Ambrosia psilostachya*) Thistle, Canada (*Cirsium arvense*) Toadflax (*Linaria vulgaris*)

HIBOR effects a rapid knockdown of existing vegetation at application time. Kill of perennial root systems in the soil and residual control of seedlings is achieved from this formulation.

As with most other herbicides, excellent results are obtained when HIBOR is applied to young and actively growing vegetation, but, due to its contact action, it may also be applied over a longer period of the growing season than the organic herbicide component alone.

Control of General Vegetation

		Per Cent Control	
Location	Rate/Acre	Maintenance	Initial Application
Northern States	100 Gallons	94	64
	150 Gallons	97	82
	200 Gallons	98	90

Location	Rate/Acre	One Treatment	Two Treatments
Southern States	100 Gallons	57	92
	150 Gallons	72	97
	200 Gallons	84	--

On Johnson grass, it has been found that treatment at heading time is more effective in obtaining a good kill than earlier applications. Control of fall seedlings of Johnson grass is also accomplished by this timing which is not always the case with herbicides applied in the spring.

A series of plots was established in the spring of 1964 in the Southern and Central United States, in which double applications (four weeks apart) of HIBOR at 100 and 150 gallons per acre were tested against single rates. It would appear that, in general, a single heavy application is almost equal in performance and certainly cheaper than the double application. For example, 200 gallons in a single application resulted in 84% control of all vegetation while the same amount of HIBOR applied as two 100-gallon treatments gave 92% control.

Bermuda grass was the species found to be the hardest to kill in these trials but 100% control was obtained for the 1964 Season using a double application of 150 gallons of HIBOR.

Although HIBOR was designed primarily for railroad use and is sold in tank car quantities, it is a useful herbicide for the commercial applicator.

FUNDAMENTALS OF DRIFT CONTROL BY DROPLET SIZE SELECTION AS APPLIED TO BRUSH CONTROL WITH THE RHAP-TROL* SPRAY SYSTEM

Lyle O. Hill[1]

My title and the information contained in this paper may be applied to any herbicide, pesticide, or sprayed material with any known method of application.

When 2,4-D was first used to kill a weed, a new era in man's control of nature was introduced. This chemical's value, still unequalled, is due, first, to its tremendous activity, and, second, to its undreamed of selectivity.

Probably no other single chemical has saved the human race so many man-hours of back-breaking labor as has 2,4-D. It has thereby improved our standard of living more than any recent wartime development. Ten years ago, it was estimated that a chemical worker in a 2,4-D plant could kill more weeds than 5,000 men working from sunup to sundown with a hoe. I would guess that our modern production methods have by now made this chemical laborer about twice as efficient as he was years ago.

In 1945, I started producing and selling 2,4-D. It was during this first season that I was confronted with a damage claim against one of our customers. While spraying the weeds in his back yard lawn, the customer sprayed his neighbor's grapes along their adjoining fence. You can guess the rest of the story.

The damage claims blamed on 2,4-D during these twenty short years is staggering. If all the claims which were taken to court or settled out of court could be totalled, I believe they would exceed a billion dollars. In spite of the out-lawing of 2,4-D in many places and the threat of its being barred in many other places, the use of 2,4-D has grown in both pounds of acid and acres treated every one of these twenty years. Its value has been many times these damage claims, which explains its continued growth.

We, who have constantly faced this costly drift problem, have continually searched for a way of applying 2,4-D and 2,4,5-T with less hazards to adjoining crops. Granules, invert emulsions, and thickening agents, all of which were used with pesticides and other herbicides before the discovery of 2,4-D, are being restudied with many innovations.

A herbicide is needed and is used to kill misplaced plants in turf, pineland, right-of-way, or rangeland. It must perform the service of killing these weed plants, be they brush or succulent plants, or this herbicide is of no value.

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* Trademark of Hercules Powder Company.

[1] Synthetics Department, Hercules Powder Company, Wilmington, Delaware.

It follows then that in the application of a herbicide, the first consideration must be to kill the weed plants. The second consideration is safety in application, that is, applying the herbicide with as little drift as possible.

To kill weed plants, Dr. Richard Behrens and others have shown that a certain minimum number of droplets of the spray mixture which contains the herbicide are required on each square inch of leaf surface. This can be as low as 20 drops of a 2,4-D mixture on a succulent plant or as high as 70 drops of a 2,4,5-T mixture on a mesquite bush.

To determine drift, Stoke's Law can be used to compute the rate and, therefore, the time of fall of droplets of different size, as noted on page 23 of Dr. S. F. Potts' book, Concentrated Spray Equipment, Mixtures, and Application Methods.[1] The drift of a droplet is the distance a crosswind will blow it during the time required for it to fall. Therefore, you can see that Stoke's Law is fundamental to our problem. My old Physical Chemistry Text gave the equation for Stoke's Law in this form:

$$v = \frac{2gr^2(p-p_1)}{gn}$$

v = velocity at which a particle drops
g = force of gravity
r = radius of the particles
p = density of the particles
p_1 = density of air
n = viscosity of air

Would you know how to use this form of Stoke's equation? It requires metric units, and, unfortunately, we are accustomed to using a more cumbersome set of English units. By using a combination of units from each set and making a couple of assumptions, we can reduce this equation to a very simple and usable form:

$$D = 1.49 \times 10^4 \frac{VH}{R^2}$$

D = drift distance in feet
V = wind velocity in miles per hour
H = drop distance in feet
R = droplet diameter in microns

Now with a workable equation, let us study the minimum calculated drift and coverage. We can calculate how far a droplet of 100 microns (which is typical of droplets in a conventional spray system) will drift if it is sprayed at a height of 50 feet with a crosswind of 1 mile per hour. The equation then becomes:

$$D = \frac{1.49 \times 10^4 \times 50 \times 1}{(10^2)^2} = 75 \text{ feet of drift}$$

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1 Potts, Samuel Frederick. 1958 Concentrated Spray Equipment, Mixtures and Application Methods. Dorland Books, Caldwell, New Jersey. pp. 23.

You can see that if the 100 micron droplet is sprayed from a height of 5 feet, the drift is only 7 feet 6 inches or 0.1 as much.

We can make a similar calculation for a droplet of 590 microns, which is median diameter produced by the Rhap-Trol System. The equation becomes:

$$D = \frac{1.49 \times 10^4 \times 50 \times 1}{(5.9 \times 10^2)^2} = 2 \text{ feet } 2 \text{ inches}$$

Now let us look at Table I in which we have compared the distance droplets of 100, 300, 590, and 800 microns will drift when sprayed at 50 feet high in a crosswind of 1, 5, and 10 miles per hour. These could be conditions found when spraying a utility right-of-way with a helicopter.

TABLE I

PREDICTABLE DRIFT OF DIFFERENT PARTICLE SIZES WHEN SPRAYED AT 50 FEET

Diameter of Particles in Microns*	In Crosswinds of 1 Mile Per Hr.	5 Miles Per Hr.	10 Miles Per Hr.
100	75 ft.	375 ft.	750 ft.
300	8 ft. 4 in.	42 ft.	83 ft.
590	2 ft. 2 in.	10 ft. 8 in.	21 ft. 5 in.
800	1 ft. 3 in.	5 ft. 9 in.	12 ft.

* One Micron = 1/25000 inches, or 1/1000 millimeters.

Now let us look at the same particles sprayed at a height of 5 feet which would approximate roadside spraying conditions in Table II.

TABLE II

PREDICTABLE DRIFT OF DIFFERENT PARTICLE SIZES WHEN SPRAYED AT 5 FEET

Diameter of Particles in Microns*	In Crosswinds of 1 Mile Per Hr.	5 Miles Per Hr.	10 Miles Per Hr.
100	7 ft. 6 in.	37 ft. 6 in.	75 ft.
300	9 in.	4 ft. 3 in.	8 ft. 4 in.
590	3 in.	1 ft. 1 in.	2 ft. 2 in.
800	2 in.	6 in.	1 ft. 3 in.

* One Micron = 1/25000 inches, or 1/1000 millimeters.

From these tables you can see how dangerous droplets of less than 300 microns can be when sprayed at 50 feet or higher and how far they will drift even when sprayed only 5 feet from the ground. We noted earlier that a minimum number of droplets per square inch of leaf surface are required to kill plants, that is, 20 per square inch of leaf surface for succulent plants and up to 70 for a mesquite bush. Table III shows the number of droplets one gallon would theoretically spray to each square inch if uniformly sprayed over an acre, assuming each droplet to be the size stated. This table also gives the expected drift when sprayed at a height of 50 feet in crosswinds of 10 miles per hour.

TABLE III

COMPARISON OF NUMBER OF DROPLETS AND DRIFT FOR VARIOUS PARTICLE SIZES

Diameter of Particles in Microns*	Calculated Number of Droplets Per Square Inch Per Gallon/Per Acre	Calculated* Drift - 50 ft. Height in 10 M/W
100	1,164	750 ft.
300	52	83 ft.
590	5.6	21 ft. 5 in.
800	2.6	12 ft.
1000	1.1	7 ft. 6 in.

* Measurements of Drift made by Brooks** are about 10% greater than these calculations show. The difference could be due to shapes of dust particles which he studied.

** Brooks, F. A., 1947, "The Drift of Poisonous Dusts Applied by Airplane and Land Rigs", Agricultural Engineering, 28(6)233-239.

Thus, droplets large enough to contain the drift, but still small enough to spray the required number of droplets per square inch to kill, are now a commercial reality. Droplets of 590 micron median diameter are sprayed with our Rhap-Trol Spray System by a helicopter equipped with our standard nozzle, flying at 30 miles per hour at 50 feet. This spray will give good kill at low gallonage per acre; for example, 4 gallons of product gives 23 droplets per square inch as shown by Table III.

Our Rhap-Trol Spray System uses a bifluid nozzle to apply an invert emulsion (water in oil) of a very high yield point. With this high yield point, achieved in the nozzle chamber as the emulsion is formed and sprayed, the wind, be it from the speed of an aircraft or from a fan, will not cause the droplets to break up after they are formed until they reach the weed. The invert droplets cannot become smaller while falling due to water evaporation because they are completely incased in oil which evaporates very slowly. Of the total volume of the mixture sprayed, 99.7% is sprayed in droplets larger than 300 microns with a 590 micron median diameter. When water is the continuous phase, the volume under 300 microns may be 100 times greater or as much as 30% of the total volume sprayed.

SUMMARY

1. Money saved in weedy plant control with 2,4-D and 2,4,5-T spurs continuous growth in face of drift damage.

2. This workable Stoke's Law equation with known facts reported here about droplets needed to kill weeds predict safest selection of droplet size.

3. The Rhap-Trol System, which will be commercially available in 1965, is containing the drift within definite limits and killing weedy plants because it is approaching this safest selection of droplet size.

4. Other advantages inherent in this spray system are:

   A. Low gallonage can be used for economy.

   B. High crosswinds may be tolerated when sprayed at low altitudes, resulting in more spraying hours during spraying season.

   C. Evaporation, which decreases the droplet size, is checked by the continuous outer oil film inherent to an invert emulsion, which is water particles surrounded by oil.

   D. The Rhap-Trol System can spray on the target area 99.7 per cent of the spray volume. The drift from the target area with water or oil-in-water sprays may be as much as 30 per cent.

PROBLEMS AND NEEDS OF RAILWAYS IN VEGETATION CONTROL

By

Charles F. King
Assistant Engineer
Chesapeake and Ohio Railway
Huntington, West Virginia

As an introduction to the upcoming panel discussion on railway vegetation control, I would like to discuss what I believe to be some of the major vegetation control problems and needs of the railway industry.

One of the major problems I face, and I'm sure most of us face, is the problem of selling management on the importance of effective and efficient vegetation control. Maintenance labor is disappearing and maintenance budgets get smaller year by year. Chemical herbicides have done much to replace the loss of labor, but many of us have been unable to offset a reduction in hand labor with a reasonable increase in chemical herbicide budgets. Even though uncontrolled weeds and brush can influence either directly or indirectly the problems of railway maintenance and operations, most railroads allocate less than two per cent of their total maintenance budgets on weed and brush control chemicals.

Consequently, lacking both sufficient labor and sufficient funds for chemicals, many of us responsible for railway vegetation control are placed in the frustrating position of having to skip sections of the line, or lower application rates of materials in an attempt to spread them farther.

Another problem common to all in railway vegetation control is state, county, and local regulatory laws which can dictate certain vegetation control requirements, or, on the other hand, restrict a railway's use of certain herbicides.

Many of these laws are justified, yet just as many benefit a few at the railroad's expense. Several of these laws are already in the books, several are now pending, and I'm sure there will be more in the future, yet the railway industry still has no common "spokesman" to present its case or even keep abreast of pending legislation.

A third problem most railways contend with is a lack of good information on vegetation control. It is this problem that has prompted many of us to attend this conference. I believe we are all aware that the key to efficient vegetation control is knowing how much of what chemical is going to provide the best control for a specific vegetation problem. But, too many of us in the railway industry have little knowledge of what's available to meet our specific needs. Most of us have relied on others for answers to our vegetation problems instead of seeking the answers ourselves. It is my belief that until railways are willing to devote time and money in training their own personnel to select, judge, and evaluate chemicals in accordance with their own specific needs, then, and only then, will they be able to obtain the most efficient vegetation control.

A case in point is the Chesapeake and Ohio Railway, which, for a number of years, contracted for a vegetation control job to be done, not for what they believed was needed to do the job. The results were not the best. Repeated yearly applications of one or two chemical formulations resulted in a heavy infestation of weed species resistant to the materials applied. Or, in other words, the C&O had not achieved a $1 worth of weed control for a $1 spent.

Today, after three years of writing their own specifications for vegetation control, the C&O has achieved better control with substantial savings.

In summary, I would like to offer some thoughts on what I believe is needed to help solve some of the railway industry's vegetation control problems.

First, the railway industry needs more help from chemical suppliers and applicators in selling management on the need for a greater chemical expenditure to combat the loss of hand labor.

Second, the railway industry needs an active agency to keep tabs on pending state, county, and local vegetation control legislation.

And, third, the railway industry needs more active and objective information sources on vegetation control. Many tests are conducted each year by railways, suppliers, and applicators, but very few results from these tests are passed on to other railways. Furthermore, the Committee of the American Railway Engineering Association dealing with this matter and many others, could be a major source of vegetation control guidance, but up to now it has been of limited value. Of about $20,000 spent annually by this group, only $600 is allocated for vegetation control research. This equals the amount spent for termite control research and about half that spent for investigation of long-range weather forecasting. It is my hope that some day soon an AREA committee will be established which would not only conduct an active vegetation control research program, but would also correlate, evaluate, and distribute vegetation control research information from all sources to all railways.

# # # # # #

11/17/64

VEGETATION MANAGEMENT IN THE NATIONAL PARKS

W. Dean McClanahan [1]

We in the United States are a restless people. We are unwilling to leave things as we find them, but are continually trying to make changes and modifications. When we find something big, we begin to plan how to make it bigger and usually more powerful. We probe into the world of the minute with an inquisitive eye, but we do not stop at observation. We attempt to take the "ultimate" particle apart and make new and different combinations. Thus, we are constantly changing our environment.

No one can argue with the wisdom of this philosophy, particularly when applied to the field of agriculture. The frightening worldwide population explosion and the resulting demands for food and fiber will place ever-increasing challenges before the sciences of chemistry and technology.

This same population explosion is placing parallel pressures upon our rapidly diminishing open spaces for use as parks and playgrounds to meet the varied but rapidly growing demands for outdoor recreation. Accelerating trends toward urbanization and industrialization of our society will further intensify these demands. Wise use of our natural resources--the land and water, the fish and wildlife, the forests and range and seashores--must be broad enough to encompass the psychosomatic man as well as the physical one. Use of land for human enjoyment and inspiration, for recreation and re-creation, must share with the more mundane uses for production of food and fodder and fiber.

The National Park idea is founded upon this concept of land use. Since the establishment of Yellowstone National Park in 1872, the National Park System has been widened to include 202 areas, totaling more than 26 million acres of land and water resources. The System represents a national trust--a trust that embraces much of this country's outstanding scenic grandeur and vestiges of natural America, along with cherished traces of our national heritage. These parks are an important part of America today. Equally important, they together represent a vast heritage that we will leave our descendants. The use of these parks must, therefore, be directed into those pursuits that will leave them unimpaired. Emphasis must be placed on viewing, understanding, and appreciating the basic land and natural resources that made this Nation strong, and on contemplating and comprehending the makeup of this Nation and of the American pioneer.

The National Park System, however, is not sufficient for meeting current demands resulting from our cultural changes, to say nothing of what tomorrow

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1 Forester, Division of Resources Management and Visitor Protection U. S. National Park Service, Washington, D. C.

will bring. The need for expansion of the System and the problems facing such expansion represent a quiet crisis. Open space is rapidly diminishing, and inflated land values will soon prohibit acquisition of nationally significant areas containing landscapes and seashores representative of natural America, and vestiges of our historic past. The same crisis faces all levels of government and conservation minded groups and individuals throughout the Nation. State and county parks, as well as private recreation developments, are essential parallels to the National Park System in that they provide simple outdoor play space and opportunities for active recreation pursuits associated with picnicking, camping, swimming, boating and skiing. These must be expanded. What we save today may well be all that our descendants will ever have. Now is the time for action, for in the words of Secretary of the Interior Udall, "Time is our enemy."

While acquisition and development of new parks and recreation areas is urgent, we must not lose sight of our responsibility for protecting and maintaining those areas that are existing and in use. Basic park values, whether natural, historical or recreational in purpose, must be preserved, yet open to full public use and enjoyment. For in the final essence, parks are for people.

Management of the National Park System offers a major challenge. Consider first the distribution of these many national parks, monuments, historic sites, parkways, recreation areas, seashores, memorial and battlefield parks, and other areas including the complex of memorials and parks within the Nation's Capital. These units are located within nearly every State of the Union, including Alaska and Hawaii, as well as the Virgin Islands. They range in altitude from Death Valley, the lowest point in the United States, to Mount McKinley, the highest point. Climatic conditions vary from extremely arid conditions in many southwestern desert areas to the rain forests of Olympic National Park. Soils range from the unstabilized sands along seashores and in Great Sand Dunes National Monument to the heavy and easily compacted loams of Homestead National Monument. Water resources also present extremes, ranging from dry southwestern desert areas to the swamps of the Everglades.

Vegetation is perhaps the most singly important natural resource within the Park System, both for its aesthetic and ecological values and its shade and shelter that contribute so profoundly towards visitor use and enjoyment of the parks. It is extremely variable and complex, embracing every type of natural plant community native to the United States. Vegetative types range from vast virgin forests of the West to the mixed hardwood forests of the East, from alpine meadows and segments of virgin prairie to vast cactus "forests," and from dry sagebrush flats to swampy glades. Extreme differences are inherited by these types in their resistence to heavy and repeated impact of human use. Vegetation in many parks in the humid southeast can apparently withstand heavy use, while the alpine vegetation of Rocky Mountain National Park and much of the desert vegetation in southwestern areas is extremely fragile, and even slight impact will alter the natural composition.

Maintenance and protection of vegetation is thus one of the most important aspects of National Park management. Quality of human experience, preservation of natural, historical, or recreational values, and protection of physical and landscape improvements are largely dependent upon proper vegetation management. This program is directed towards control of noxious and exotic plants, lawn weeds and hardwood sprouts, or any plant growing in undesirable locations, and closely correlated with programs relating to visitor use, park development, forestry and fire control, and soil and moisture conservation.

Presence of noxious plants such as poison ivy and ragweed within public use areas create hazards and interfere with full visitor use and enjoyment of National Parks and related areas, and must be eliminated. Various noxious plants are also covered under domestic plant quarantine regulations and must be controlled to reduce their occurrence and prevent their encroachment onto noninfested areas. The Canadian thistle is one of these.

Many exotic plant species have become introduced into parks preserved as natural areas, and while only a few of these are considered noxious, all must be eliminated so far as practical as required by Congressional mandates and related management policies. Under these policies, preservation of natural areas further requires control of woody plant species encroaching upon and threatening existence of scenic mountain meadows and virgin prairie complexes.

High-growing vegetation, particularly hardwood sprouts, must be reduced at predetermined locations along trails and scenic drives for maintenance of vistas so important to visitor enjoyment of the National Parks and related areas. Encroachment of vegetation onto roadways, trails, retaining walls, guard fences, parking areas, drainage gutters and sewage lagoons detracts from such improvements and contributes to maintenance costs. Complete elimination of such plant growth is usually necessary. Plant growth regulators have also proved effective in facilitating roadside maintenance and reducing maintenance costs.

Control of vegetation adjacent to structures, near liquified petroleum gas installations, along utility and fire roads and within fire breaks is essential for proper fire protection.

Preservation and maintenance of historic structures, waterways, wagon roads and races, battlefields and fence rows require management of a wide variety of vegetation. Woody plants are usually eliminated in such programs, with grasses retained to prevent soil erosion. Archeological ruins particularly require elimination of all vegetative growth from such ruins for their stabilization and preservation. Maintenance of lawns, especially within the National Capital Parks and numerous historical parks, requires control of the many common lawn weeds and undesirable grasses.

Overall, the many aspects of the vegetation management programs within the National Parks can be accomplished more economically and satisfactorily with herbicides than by mechanical or other means currently available. The various

herbicides used include contact, translocative, selective, and soil residual toxicant types, chosen for use on the basis of specific program objectives. Methods and rates of application and time phasing are determined by characteristics of the plant species to be controlled, and by variable conditions such as plant associations, site and climate. Specific products used are dependent upon those available within the local trade area.

Recommendations of various Federal advisory agencies, including the Agricultural Research Service and the Fish and Wildlife Service, are followed in developing various aspects of the overall program. Technical guidance and assistance are occasionally provided by these agencies. Research and extension services of State colleges, State fish and game commissions, public health departments, and plant quarantine or weed control commissions are consulted on local programs.

All known and accepted precautions associated with storage, handling and application of herbicides are taken to avoid adverse effects. These precautions include use of trained personnel, discontinuance of spray operations when wind velocities exceed five miles per hour, strict adherence to prescribed formulations and rates, and close supervision to avoid contamination of surface waters. Operations within public use areas are, where practical, conducted prior to heavy use seasons or when public use is light. Agricultural land and food or forage crops are not involved in these programs.

In summary, we recognize that in our planning today there must be vigorous protection of resources that will guarantee posterity the same right to decide the fate of these resources that our ancestors gave us. We cannot accurately envision the America of tomorrow. All we can do is our intelligent best to leave future generations some resources of nature and give them the privilege of deciding further what to do with them. We trust they will honor us for our wisdom in leaving them opportunity in their time for honest utilization of resources for the spiritual and physical needs.

A METHOD OF APPLICATION OF INVERT EMULSION OF 2,4-D ON WEEDS GROWING ON A HIGHWAY RIGHT-OF-WAY[1]

T. O. Evrard, W. E. Chappell, and L. O. Hill[2]

Applications of invert emulsions have been used to control drift of certain herbicide formulations from aircraft. A method to apply invert emulsions of 2,4-D and 2,4,5-T with ground equipment along highways is being tested and is reported herein.

As reported by other workers, an air blast into which chemicals are injected has been used to apply growth regulators to grass, and standard emulsion phenoxy herbicides to brush along railroad and highway rights-of-way. In this study an attempt was made to use this air blast or "air carry" to distribute an invert emulsion of 2,4-D at varying distances from a moving vehicle. A bifluid system for preparing invert emulsions, that is, the mixing of herbicide, chemical and water at the nozzle to form an invert was used in these experiments. Without some means of propelling this heavy emulsion the distance that can be covered by the spray is not great, and is time consuming. It was thought that the effective swath could be greatly increased by the use of an air blast.

In the summer of 1963 bifluid hand guns were mounted in front of a Myers RW29 air carrier and several preliminary tests were made.[3] The results from this preliminary test were encouraging. Later that year a boom with 16 bifluid nozzles was assembled and installed in front of the air blast, but it was felt that this number of nozzles was too cumbersome. Further development by the equipment and chemical manufacturers during the winter of 1963-64 produced several less complicated inovations. A boom with 5 bifluid nozzles (each 3/4 GPM at 30 psi) was assembled so that the piping would be outside the air blast. Several nozzle tips were tried and although some worked satisfactorily, this phase needs more research. With the newer boom a swath width of 30 feet was obtained.

The latest boom consists of a uni-trace pipe (pipe within a pipe, one to carry chemical and the other to carry water) and 5 bifluid nozzles. To supply this boom two Hypro pumps were used connected by a single drive shaft to a 7 hp gasoline engine. A 55 gallon drum was used as a water reservior and a 20 gallon drum contains the herbicide. Both drums have outlets and valves at the bottom so that a constant supply can be maintained at the pumps and so that either can be shut off in order to check the system.

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[1]Project supported in part by the Virginia Council of Highway Investigation and Research, U. S. Bureau of Publis Roads, and Virginia Department of Highways.

[2]Instructor and Professor of Plant Physiology, respectively, Virginia Agricultural Experiment Station, Blacksburg, Virginia and Phenoxy Herbicide Division, Hercules Powder Company, Wilmington, Delaware.

Results to date show that the effective swath width is between 30 and 35 feet. It also appears that the maximum engine speed of the blower should not exceed 17-1800 rpm (about 1/2 to 2/3 throttle). Higher engine speeds give wider swaths but with the nozzles now in use (with orifices .029 or .035 inches) droplet break-up occurs and causes drift.[3]

To test the effectiveness of this equipment an experiment was initiated on October 8 comparing the effect of 2,4-D (2 ethyl hexyl ester) invert emulsion and 2,4-D dimethylamine salt. The weather was clear and cool (40-50°F) and prior to this time periodic rains were received and the grass and perennial weed growth was favorable.

The plots were located along the shoulder of the southbound lane on Interstate Highway 81 east of Pulaski, Virginia. Plant growth consisted of Kentucky 31 fescue, bluegrass, dandelion, buckhorn, chicory and other mixed perennial broadleaved weeds.

Plots, Chemicals and Equipment

Plot 1 - extending approximately one mile. Two lb of 2,4-D/A as the 2 ethyl hexyl ester in an invert emulsion form. A total of 8 gal/A (7 gallons water + 1 gallon herbicide/A). Five bifluid nozzles were mounted in front of an RW29 air carrier. Nozzle pressure was approximately 40 psi. The air carrier was operated at approximately 1/2 throttle. Swath width was 26-30 feet; truck speed was 7.5 mph.[4]

Plot 2 - approximately 1½ miles. Two lb of 2,4-D as the dimethylamine salt in 50 gallons water/A. Applied by using a TOC 150 nozzle at 30 psi, truck speed 6 mph. Swath width 20 feet.

Results

On plot 1, the invert plot, three sets of four one foot square plastic covered cards were placed along the shoulder at the following distances and the droplets in one square inch were counted and recorded. Ten 1 inch square counts were made per card.

Feet in from edge of shoulder	3 locations, count/sq. in. avg. 10 counts on each card
2-3	16,17,18
6-7	17,16,21
15-16	37,21,19
24-25	21,14,14

[3] F. E. Myers and Company.

[4] Highway spray truck supplied by F. A. Bartlett Tree Expert Company.

Weed control observations taken October 20 and November 16 showed that the invert emulsions at rates used controlled broadleaf weeds better than the solution herbicides applied by the OC nozzle. The perennial broadleaf weed control readings taken November 16 are as follows:

	(Avg. 10 observations)
2 lb 2,4-D 2 ethyl hexyl ester invert emulsion (8 gal total solution)/A	90%
2 lb 2,4-D dimethylamine salts (50 gal total solution/A	65%

However, this could be attributed to the differences in effects of the ester versus amine salt formulations of 2,4-D

This equipment appears to be favorable for use in controlling brush along railroad and highway rights-of-way.

COMPARISON OF CERTAIN 2,4-D FORMULATIONS FOR CONTROL OF BROADLEAF WEEDS DURING MID-SUMMER APPLICATION[3]

T. O. Evrard and W. E. Chappell[1]

It is believed that due to conditions of weed growth late July and August are not ideal times to control broadleaf weeds with herbicides.

However, because of the availability of man power, equipment, and moneys, many highway districts find it necessary to spray during this period. For this reason, two experiments (A and B) were put out to test rates of application and effectiveness of different 2,4-D formulations when applied during August.

Experiment A: Broadleaf Weed Control Trial on Interstate Highway 81, Salem Bypass.

Material and Method: On July 30 and 31, 1963, a field experiment was put out on Interstate Highway 81 near Salem, Virginia, comparing the effectiveness of certain formulations of 2,4-D. The 2,4-D formulations are as follows:

1. Low volatile ester (Butoxyethanol) emulsifiable concentrate.
2. Water soluble amine salt (Dimethyl amine salt).
3. Oil soluble-water emulsifiable amine salt (Oleyl 1,3-propylene diamine salt)[2].

All herbicides were put out at 1½ lb. in 50 gallons of water/A. The equipment used was a truck equipped for highway spraying with a Myers air carrier and OC nozzles[4]. The OC nozzles and air carrier were used depending upon terrain.

Predominant weed species present were ragweed, smartweed, lambsquarter, and Jimson weed. The weather was partially overcast and temperature was 80-95° F. Each plot was 3/5 acre and replicated three times.

Weed control readings were taken on September 3 and September 18, 1963, with several readings taken in each plot. Results were analyzed by the Duncan multiple range tests.

[1] Instructor and Professor of Plant Physiology, respectively, Virginia Agricultural Experiment Station, Blacksburg, Virginia.

[2] Dacamine.

[3] Supported in part by the Virginia Council of Highway Investigation and Research, U. S. Bureau of Public Roads, and Virginia Department of Highways.

[4] Truck furnished by Bartlett Tree Expert Company.

Results:

Table I. Percent of Broadleaf Weed Control (Average of Three Replications) on Interstate Highway 81, Salem By-pass.

Treatments	Dates of Evaluation	
	September 3	September 18
Low Volatile Ester E.C.	68.3	87.3* a
Dimethyl amine	76.6	66.7 b
Oleyl 1,3 propylene diamine salt	85.0	96.0* a

* Figures followed by the same subscript are not significantly different at the 5% level.

Using the data collected September 3, no significant differences were noted in percent weed control. However, data taken September 18 showed significance at the 5% level. The low volatile ester (Butoxyethanol) and Oleyl 1,3 propylene diamine salt were significantly more effective than the Dimethyl amine salt.

Experiment B: Broadleaf Weed Control Trial on Interstate Highway 81, Chilhowie, Virginia.

Material and Method: On August 2, 1963, a field experiment was put out comparing the effectiveness of the water soluble amine salt of 2,4-D (Dimethyl amine) and an oil soluble water emulsifiable amine salt of 2,4-D (Oleyl 1,3 propylene diamine salt of 2,4-D) at ½ and 1 lb ae/A.

The formulation and rates are as follows:

1. ½ lb. 2,4-D ae in 50 gal water/A (Oleyl 1,3 propylene diamine salt)
2. 1 lb 2,4-D ae in 50 gal water/A (Oleyl 1,3 propylene diamine salt)
3. ½ lb 2,4-D in 50 gal water/A Dimethyl amine salt.
4. 1 lb 2,4-D in 50 gal water/A Dimethyl amine salt.

Equipment used was the same used in Experiment A.

Predominant weed species present were ragweed, smartweed, lambsquarter, chickory, Jimson weed and wild turnips.

The weather was clear and very calm; the temperature was 85-90°F. Each plot was 3/5 acre in size.

Weed control ratings were made September 20, 1963 and submitted for statistical analysis.

Results:

Table II. Percent of Br dleaf Weed Control - Average of Two Replications and Three Readings at Each Replication. Interstate Highway 81, Chilhowie, Virginia.

Treatment	Control*
Oleyl 1,3 propylene diamine salt of 2,4-D ½ lb/A	90 a
Oleyl 1,3 propylene diamine salt of 2,4-D 1 lb/A	85 ab
Dimethyl amine salt ½ lb 2,4-D/A	45 c
Dimethyl amine salt 1 lb 2,4-D/A	65 bc

* Figures followed by the same subscript are not significantly different at the 5% level.

Discussion - Experiments A and B:

Significant differences were noted. One-half pound of 2,4-D in the Oleyl 1,3 propylene diamine salt formulation was significantly more effective than the ½ or the 1 pound rate of 2,4-D in the Dimethyl amine formulation. The results also showed that 1 pound of 2,4-D in the Oleyl 1,3 propylene diamine salt formulation was significantly more effective than ½ pound of the 2,4-D in the Dimethyl amine formulation. No significant differences were noted when comparing 1 pound of 2,4-D in Oleyl 1,3 propylene diamine salt form to 2,4-D in Dimethyl amine form.

It was noted that in plants that received the 2,4-D in the dimethyl amine salt formulation, seed heads of annuals (ragweed and lambsquarter) formed and produced seed even though their stems were severely twisted by chemical effects. Seed heads of lambsquarter and smartweed were collected from treated and untreated plants and germinated in the greenhouse. The lambsquarter seed from both treated and untreated plants germinated in large amounts and no differences were noted. Very few ragweed seeds germinated from either treatment and no differences were noted in those which did germinate.

Because of the dry weather the plants were under a moisture stress. Weeds of all stages of growth were present in the experimental plots and all treatments controlled the young plants. However, as can be seen from the results of these two experiments, the water soluble amine salts (Dimethyl amine salt) of 2,4-D are not very effective when applied in late July and early August of this past year at rates of ½ to 1 lb/A. The oil soluble water emulsifiable amine salt (Oleyl 1,3-propylene diamine salt) of 2,4-D and the low volatile ester (Butoxyethanol) forms of 2,4-D produced desirable results in these trials. The Oleyl 1,3-propylene diamine salt did perform somewhat better than the low volatile ester in the trial at Salem but no significant differences were noted in the analysis. All chemicals and all rates tried had no effect on Jimson weed in these experiments.

STUDY OF A LIQUID-FORMULATED SOIL STERILANT INCORPORATED WITH RT-4 TAR FOR GUIDE RAIL WEED CONTROL

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OBJECTIVE

In June, 1961 an experiment was designed to compare various rates of a liquid-formulated soil sterilant:

1) Sterilant mixed with an RT-4 tar prior to the application of the tar to soil under a guide rail *
2) Tar applied to the soil without a sterilant
3) Tar applied to soil treated with a water-suspended sterilant **

MATERIALS AND METHODS

Four replicate sections of each treatment were placed under guide rails along both sides of Route 116, Harwinton, on a four mile section in June, 1961. The site selected was of new construction and there was no vegetative growth on the soil under the guide rails.

The liquid-formulated soil sterilant was poured into the tank of the tar distributor and thoroughly mixed before application. The tar was kept at a temperature of about 150°F during mixing and application.

Note

* Liquid Urox, 1961 formulation, probably urox in an oil carrier, General Chemical Division.

** Simazine 80W, Geigy Chemical Company

Paper prepared for the 1965 NORTHEASTERN WEED CONTROL CONFERENCE

The treatments were as indicated:

Treatment A - Tar placed under guide rail without a soil sterilant at the rate of 2362 gallons per acre. About 0.22 times more than the planned application rate of 1936 gallons per acre.

Treatment B - Tar placed immediately over an application of water-suspended soil sterilant. Tar applied at 2362 gallons per acre; 80% soil sterilant placed at 7 lbs per acre suspended in 50 gallons of water.

Treatment C - Tar with liquid-formulated sterilant mixed and placed at 2362 gallons of the mixture per acre. Two gallons of liquid-formulated sterilant per 1400 gallons of tar. 10.11 lbs technical sterilant per acre.

Treatment D - Tar with liquid-formulated sterilant mixed and placed at 2190 gallons of the mixture per acre. Four gallons of the liquid-formulated sterilant per 1400 gallons of tar. 18.78 lbs technical sterilant per acre.

Treatment E - Tar with liquid-formulated sterilant mixed and placed at 2188 gallons of the mixture per acre. Seven gallons of the liquid-formulated sterilant per 1400 gallons of tar. 32.79 lbs of technical sterilant per acre.

Treatments A, B, and C applied June 20, 1961 and treatments D and E applied June 21, 1961. 20th warm and dry; 21st, cloudy, occasional light rain.

COST COMPARISON FOR MATERIALS (1961 Prices)

Treatment	Liquid Sterilant	80W Sterilant	RT-4 Tar	Total Cost Per Square Yard
		COST PER ACRE		
A	- -	- -	$432.00	$0.0893
B	- -	$46.93	$432.00	$0.0990
C	$42.13	- -	$432.00	$0.0960
D	$78.25	- -	$401.00	$0.0990
E	$136.66	- -	$400.00	$0.1109

Based on actual rates used in test. No spray truck or spray crew used except for Treatment B.

OBSERVATIONS

No weed control measures have been required on any of the plots from 1961 through 1964. Some additional weed control sprays might be required during 1965 for control of crabgrass growing in winter maintenance sand deposited on top of the tar cover. Observations made on June 21, 1964 indicate the following:

Treatment A - Minor cracking of the tar cover. No significant plant growth in plots.

Treatment B Minor cracking of the tar cover. No significant plant growth in plots.

Treatment C - Minor cracking of the tar cover. No significant plant growth in plots.

Treatment D -.Very little cracking of the tar cover. Tar cover in general appears to retain more elasticity than the tar of treatments A, B and C. No significant plant growth in plots.

Treatment E - Very little cracking of the tar cover but slightly more than

Note: In all plots some crabgrass was found in areas where winter maintenance sand had accumulated.

DISCUSSION

It is of interest to note that all plots offered acceptably weed free conditions for the third year after application. This result is no doubt due to the toxic quality of tar itself, the weed free condition of the application site, and the protective action of the tar cover which prevented entry of viable weed seeds to the soil surface. It is not possible at this time to evaluate the herbicidal efficiency of the two types of soil sterilants tested.

Treatment of areas under guide rail with sterilants followed by an application of asphalt or tar has been common practice in Connecticut for many years. Acceptable weed free conditions have usually been obtained for as much as 6 years. Where abrasives used in winter maintenance have accumulated under the guide rail, it has been necessary to apply weed control sprays to eliminate growth in the deposits. No growth of any significance originated below the tar or asphalt applications.

It is of interest to point out that where there was no curb and pavement run-off water crossed the treated areas, irrespective of the type or lack of soil sterilant, the tar cover consistently appeared to retain more elasticity and had less cracking and deterioration than the tar cover in areas protected from wetting by surface run-off water.

It is also curiously significant to note that in general the plots which contained the two higher rates of the liquid-formulated sterilant mixed with the tar prior to application consistently demonstrated a more resiliant and crack-free tar cover. In this respect the tar cover in Treatment D was superior to all other plots.

CONCLUSION

After three years the plots in this test were comparable and acceptable for guide rail weed control. Experience has shown that acceptable weed free conditions should persist for at least six years with a tar or asphalt cover applied over sterilized soil.

The significant findings in this test are:

1) A liquid-formulated soil sterilant can be mixed with a tar for application under guide rails for effective weed control eliminating the traditional spray crew.

2) Either the sterilant, or more probably the "oil-carrier" of the liquid-formulated soil sterilant appears to be beneficial in extending the "elastic" life of tar applied over a heterogeneous soil surface under conditions where there is no vehicular traffic to "knead" the tar.

One night speculate that additions of this type of sterilant to tars and possibly asphalts for shoulder work, or for parking lots, might provide the benefits of weed control and extended pavement life.

E. F. Button
October, 1964

EFFECTIVENESS OF CERTAIN SOIL STERILANTS ON HIGHWAY WEEDS AT DIFFERENT LOCATIONS

T. O. Evrard and W. E. Chappell[1]

In 1963 a program of complete vegetation control on Virginia highways was initiated.[2] That summer 17 chemical treatments were applied at four locations within the state. The following year these tests were expanded to 33 treatments at each location; included in the tests were the most promising herbicide tested the year before. There were three replications at each location. The locations were chosen so as to take in a wide spectrum of soil types and climates. Table 1 lists locations of experiments, date of application, date of observation, soil type and predominant species present.

Chemical applications were made in spring and early summer; readings were taken in mid fall. Chemicals, rates of application and observations at each location are shown in Tables II and III.

Treatments 1-14 were granular applications; treatments 15-32 were wettable powders, emulsifiable concentrate or solutions applied as liquids in 30 gal. of water/A.

At location IV chemical rates were one-half that of locations I, II, & III, but all treatments at this location (IV) were tar and gravel capped.

Discussion

In these experiments the main interest was in complete control of all species, and many of the chemicals showed promise in this respect. The more promising herbicides will be applied next season at more locations. Since we are interested in longevity of the vegetation-free area, observations will be made on these same experiments again next year. Some chemicals performed well at all locations, others at just certain locations. Weed species at locations I, II, and III were very similar and it is felt that species did not make the difference.

Note that because tar and gravel were applied to all treatments at location IV, the observed readings were higher than those at other locations and results are reported separately in Table III. The check (no chemicals, only tar and gravel) had a reading of 4.

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[1] Instructor and Professor of Plant Physiology, respectively, Virginia Agricultural Experiment Station, Blacksburg, Virginia.

[2] Supported in part by the Virginia Council of Highway Investigation and Research, U. S. Bureau of Public Roads, and Virginia Department of Highways.

Table 1. Locations and pertinent information on experiments.

Location #1

Brosville, Va.
Applied: May 14, 1964
Readings taken: Sept. 29, 1964
Soil: Peidmont residual
Predominant Species: Ky. 31 fescue, mixed broadleaves and serecia lespedeza.

Location #2

Pulaski, Va. IH 81
Applied: May 8, 1964
Readings taken: Sept. 24, 1964
Soil: Limestone residual; Southern Valley soil
Predominant Species: Ky. 31 fescue, mixed broadleaves.

Location #3

Harrisonburg By-pass - IH 81
Applied: August 4, 1964
Readings taken: October 5, 1964
Soil: Limestone residual Northern Valley soil
Predominant Species: Ky. 31 fescue, mixed broadleaves.

Location #4

Thornburg, Virginia IH 95
Applied: June 23, 1964
Readings taken: October 6, 1964
Soil: Coastal Plain soil
Predominant Species: Bermudagrass, mixed broadleaves.

Table II. Treatments, rates and averages of vegetation control at locations I, II, & III. Treatments 1-14 were granular applications, 15-32 were applied as liquids.

	Treatments	Rate/A	Average of 3 Readings Loc. I	Loc. II	Loc. III	Avg. 3 reps at Loc. I,II, & III
1.	Amoco Industrial weed killer T	2 lb/100 sq ft	9	10	8.8	9.3
2.	Amoco monoborochlorate	4 lb/100 sq ft	4	8.7	5.3	6.0
3.	Amoco Noxious weed killer	½ lb/100 sq ft	0	8.7	2.0	3.6
4.	Geigy Simazine 4G	20 lb/A	2.3	9.5	2.0	4.6
5.	Thompson-Hayward Casoron 10G	10 lb/A	0	4	2.3	2.1
6.	Thompson-Hayward Casoron 10G	20 lb/A	1	4.7	4.7	3.5
7.	Shell 7961 5G	10 lb/A	3	3	3.7	3.2
8.	Diamond Vacate	1 lb/100 sq ft	8.5	9.5	8.0	8.7
9.	Chipman Borea K-10	1 lb/100 sq ft	9.8	9.2	6.7	8.6
10.	General Urox 22	½ lb/100 sq ft	9.7	9.2	6	8.3
11.	Thompson-Hayward TH-073-H-5G	5 lb/A	3	3.7	3	3.2
12.	Thompson-Hayward TH-073-H-5G	10 lb/A	7	6	5	6
13.	Hooker Tritac 10G	100 lb/A	0	9.8	1	3.6
14.	Geigy Atrazine 8G	20 lb/A	9.7	8.7	4.3	7.6
15.	Geigy GS-14254	10 lb/A	4	9.5	7	6.8
16.	Geigy Simazine	20 lb/A	6.3	9.8	7	7.7
17.	Geigy Atrazine	20 lb/A	8.7	10	8.7	9.1
18.	Thompson-Hayward TH-073-H	10 lb/A	0	8	7.2	5.1
19.	Thompson-Hayward TH-073-H	5 lb/A	0	3.7	4.3	2.7
20.	Thompson-Hayward Casoron	10 lb/A	0	0.7	1.3	0.7
21.	Thompson-Hayward Casoron	20 lb/A	0	1.7	0	0.6
22.	Shell 7961	10 lb/A	1	3	0	1.3
23.	DuPont Monuron (Telvex)	20 lb/A	9.5	9.7	7.7	9
24.	DuPont Diuron (Karmex)	20 lb/A	9.3	9.7	9.2	9.4
25.	DuPont Hyvar X	10 lb/A	9.3	10	9.8	9.7
26.	Amchem Amizine	15 lb/A	4	9.7	9.8	7.8
27.	CIBA C-2059	20 lb/A	8.7	9.7	8.3	8.9
28.	CIBA Tenoran	20 lb/A	0	3.3	5	2.8
29.	Penn Salt TD 480	50 lb/A	0	1	5	2
30.	Amoco Noxious Weed killer D	2 gal/A	0	0	4	1.3
31.	Geigy Promotone 25E	7½ gal/A	1	0		2.5**
	(Location III - TCA 95%	200 lb/A)*			10	10.0***
32.	Tritac + Fenac	3 lb+ 1 lb/A	0.7	1.3	2.7	1.6
33.	Check	---	0	0	0	0

* At the ti observati were made germinati on broadl in the pl was noted.

** Average o 3 reps at locations.

*** Average o 3 reps at 1 locatio

10 = 100% control; 0 = no control

Table III. Treatments, rates and averages of vegetation control at location IV. Treatments 1-14 were granular applications, 15-32 were applied as liquids. All treatments were tar capped after application.

	Treatments	Rate/A	Average of 3 readings Location IV
1.	Amoco Industrial weed killer T	1 lb/100 sq ft	9.8
2.	Amoco monoborochlorate	2 lb/100 sq ft	3.7
3.	Amoco Noxious weed killer	¼ lb/100 sq ft	9.0
4.	Geigy Simazine 4G	10 lb/A	6.3
5.	Thompson-Hayward Casoron 10G	5 lb/A	8.8
6.	Thompson-Hayward Casoron 10G	10 lb/A	3.7
7.	Shell 7961 5G	5 lb/A	7.8
8.	Diamond Vacate	½ lb/100 sq ft	8.8
9.	Chipman Borea K-10	½ lb/100 sq ft	7.8
10.	General Urox 22	¼ lb/100 sq ft	9.7
11.	Thompson-Hayward TH-073-H 5G	2½ lb/A	5.3
12.	Thompson-Hayward TH-073-H 5G	5 lb/A	8.3
13.	Hooker Tritac 10G	50 lb/A	9.7
14.	Geigy Atrazine 8G	10 lb/A	8
15.	Geigy GS-14254	5 lb/A	7
16.	Geigy Simazine	10 lb/A	8
17.	Geigy Atrazine	10 lb/A	7.3
18.	Thompson-Hayward TH-073-H	5 lb/A	8
19.	Thompson-Hayward TH-073-H	2½ lb/A	9.2
20.	Thompson-Hayward Casoron	5 lb/A	7.3
21.	Thompson-Hayward Casoron	10 lb/A	9
22.	Shell 7961	1 lb/A	7.3
23.	DuPont Monuron (Telvar)	10 lb/A	9.8
24.	DuPont Diuron (Karmex)	10 lb/A	9.7
25.	DuPont Hyvar X	5 lb/A	9.8
26.	Amchem Amizine	7½ lb/A	10
27.	CIBA C-2059	10 lb/A	9.5
28.	CIBA Tenoran	10 lb/A	8.2
29.	Penn Salt TD 480	25 lb/A	7
30.	Amoco Noxious weed killer D	1 gal/A	9
31.	Geigy Prometone 25E	3-3/4 gal/A	8.7
32.	Tritac + Fenac	1½ lb + ½ lb/A	8.7
33.	Check	---	4

10 = 100% control;
0 = no control.

THE FLOW DEVELOPER:

A NEW SANITATION TECHNIQUE FOR NATURAL SWIMMING AREAS

by

JASON M. CORTELL[1]

Introduction

Each year the number of ponds and lakes used for public recreation is increasingly endangered by bacterial contamination, aquatic vegetation, and algae bloom.

The problems facing public health officials on state and local levels become readily apparent when one realizes that America's population will nearly double by the year 2000. At the same time, demand for outdoor recreation facilities, many of them lakes and ponds, will be tripled.[2]

This paper will deal with the above problem as it existed in one typical recreation area, Crystal Lake in Newton, Massachusetts.

Crystal Lake in Newton, Massachusetts has always been considered an ideal public swimming facility. A spring-fed pond, its 30 acres easily satisfied the swimming needs of Newton's 100,000 citizens.

This otherwise ideal situation has been marred by two stubborn problems, a recurring infestation of bacterial pollution and an abundance of aquatic vegetation.

No more than a casual observation of the Crystal Lake bathing area indicated that bacteria build-up coincided with periods of hot weather. This was caused apparently by a decrease of natural circulation in the pond. When hot weather was coupled with the inevitable increased usage at Crystal Lake, the area became a serious health problem.

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1. Consultant Biologist, 506 Harvard St., Brookline, Mass.
2. A Digest of the Report of the Outdoor Recreation Resources Review Commission, Citizens Committee for the ORRRC Report, Washington, D. C., Sept., 1964, P. 8.

A bacteria count of 2400 MPN[3] was set as a limit for safe and healthful swimming at Crystal Lake. This limit, recommended by the Massachusetts Department of Public Health, is used as a point in determining when the area should be closed to swimming. On numerous occassions in the past decade, the Newton Health Department was forced to close Crystal Lake.

Problem

A Bio-Engineering survey of Crystal Lake and its drainage area was conducted and indicated that no pollutants and contaminants were being introduced into the lake from an external source. Aside from the springs which feed a fresh supply of water into the pond, only the city's rain basins emptied into the lake.

Aquatic weed growth, however, was substantial. Almost the entire body of water, which averages 12 feet in depth, was infested with moderate to heavy growths of submerged aquatic weed species. The dominant form was *Elodea canadensis* (American elodea). Scattered along the shoreline , mainly in isolated patches, was *Potamogeton epihydrus* (ribbonleaf pondweed). In addition to these major weed species, *Nitella* sp., (musk weed) and filamentous algae were found in mud beneath the mats of *Elodea*.

It appeared that high bacteria counts and aquatic vegetation were primary problems at the lake. During a June, 1963, heat wave, it was noted that a bacteria count registered over 1000 MPN. This strengthened belief that lack of circulation or stagnation caused the contamination at the Crystal Lake bathing area.

Procedure

Bacterial Pollution

In order to eliminate the public health hazards at Crystal Lake, action was taken to induce circulation of the lake water through artificial means. This led to the development of the flow developer concept.

3. Most probable number of Coliform organisms per 100 ml.

The flow developer power unit consists of a 10 horse power submersible, electric motor with a propellor to generate water movement and create a current through the bathing area. Mounted on a floatable wooden platform, the flow developer is capable of displacing 2,000,000 gallons of water per hour. Dye tests indicated that the flow developer propelled water at such a rate that the water in the bathing area was turned over every 15 to 20 minutes. This allowed fresh, uncontaminated water from the remainder of the 30-acre lake to flow constantly through the bathing area.

To insure maximum safety against any electrical shocks from the equipment, extensive tests were carried out. These tests indicated that the equipment, provided it is well grounded, presents no hazards to swimmers. A fail-safe device was added to the equipment as a back-up stage to the primary control system.

Aquatic Weed Control

In October, 1963, chemical treatments were applied to eliminate the aquatic vegetation in the lake. Sodium arsenite was applied by means of the Chemical Injection System[4] at the rate of 10 parts per million of As_2O_3.

Algae Control

As part of the triple-phased program at Crystal Lake, copper sulphate treatments were initiated to curtail the algae bloom. The copper sulphate, in granulated form, was introduced into the lake water at a rate of 0.3 parts per million in June, 1963, using the Chemical Injection System once again. Another treatment was made after the flow developer had become operational. On this occassion, copper sulphate, ranging in quantities from 5 to 20 lbs., medium crystal, was added to the water being moved by the flow developer.

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4. Author, Progress Report on the Field Testing of Various Herbicides for Aquatic Weed Control, Proceedings N.W.C.C., Vol. 15, January, 1961, P. 533

Results

Two-year results of the Bio-Engineering project at Crystal Lake have indicated that the problem of pollution has been abated.

The flow developer became operational in early July, 1963. Its first test soon followed when another protracted heat wave, lasting 10 days, hit Newton. Bacteria counts during the period remained at a level below 10 MPN. This was in contrast to the 100-1000 MPN counts registered before the flow developer began operating.

Of 27 bacteria counts taken during the remainder of the summer, 26 registered under 100 MPN. By comparison, five of the 15 counts taken before the flow developer was installed were in the 100-1000 MPN range.

During the summer of the second year (1964) bacteria counts were taken weekly by the Newton Board of Health. At no time during the summer did the counts exceeded those recorded in the previous year.

Within 14 days after the aquatic weed treatments, *Elodea* and *Potamogeton* were dead and in the process of decay. Neither *Nitella* nor algae were significantly effected.

During the summer of 1964, an examination of the lake indicated no regrowth of *Elodea* or *Potamogeton* had occurred. Two algae control treatments were administered to keep water free of algae bloom.

Summary

By the creation of an artificially induced water current, bacterial pollution at Crystal Lake, Newton, Massachusetts, was brought under control. The flow developer proved to be an effective tool in eliminating stagnation within the bathing area.

Aquatic weed control measures have also proved successful in the rehabilitation of Crystal Lake.

MY OBSTACLE COURSE IN RAGWEED CONTROL

Mrs. Ray Schiffman

Why does ragweed exist today? Is it ignorance, apathy, or financial impracticability? Is it conceivable that a nation as powerful, as wealthy and as health conscious as we profess to be, should permit a hazard such as ragweed to survive and flourish?

The United States donates the major portion of funds toward the World Health Organization, thus contributing to the well-being of people all over the earth. Charity should in this instance begin at home...for millions of Americans.

These are the thoughts that crossed my mind when I heard my little girl on the 7th consecutive night of a week in August, restless, uncomfortable, and weary from lack of sleep. The hay fever season had begun. Unquestionably there were many such miserable days and nights ahead to be accompanied by an occasional nosebleed.

If the word "Allergist" is running through your mind during this discourse, please stop and think a moment. What percentage of Americans can really afford to be treated, and are these treatments always 100% effective? Punctually every day the pollen count is recorded and reported to the public. Informative but hardly helpful to a hay fever sufferer. There are ever so many remedies in the antihistamine family being sold via television, the radio or prescribed by a physician. Most of them have a drowsy effect, some have side effects.

Why has preventive medicine not been applied to date?

At precisely 9 a.m. the following morning I proceeded to call every Agricultural firm for available information on ragweed control. By way of referral, I obtained an informal education on the difference between a pesticide and an herbicide but most important of all, I was put in touch with Dr. Shallock at Rutgers University. Dr. Shallock was kind enough to enlighten me still further on the subject and eventually put me in touch with Mr. Zemlansky. All available literature and progress on the subject was then forwarded to me by this gentleman. The problem was now clearly defined but the solution was not!

To begin with, I contacted my local Board of Health. The officer in charge was a Mr. Gavin. At first he was enthused and encouraging, suggesting that I contact my legislators for aid. He never informed me that Linden had adopted an ordinaance

providing for weed control. This I discovered in a round-about-way and upon questioning him, he confirmed this fact. Since ragweed sufferers are most susceptible to plants nearest them, my next step was to tour the streets of Linden. I then submitted a partial list of the infested areas. End result- Complete disregard of the existing ordinance, indifference, double talk, and annoyance. This was followed by a note from Mr. Gavin thanking me for my efforts by requesting that I cease my activities.

The next step- publicity on the subject. I could not possibly do more alone. I contacted the Elizabeth Daily Journal and the following day a small article appeared describing my viewpoint on the ragweed situation. This lead to contact with a Cranford resident, who in his own way attempted to work with his Township Board of Health but had come to a dead stop. I asked Mr. Zemlansky to use his influence and contact the Cranford people. This he kindly did but upon checking the Cranford Dumps (one area in question).I found the weeds more glorious than ever. If they were sprayed, it may have been with perfume but certainly not with 2-4D. Result- Another town- another case of complete indifference.

I then called the Newark News...and tendered what information I had on the subject but referred the reporter to Dr. Shallock for technical data. I did ask him to please try and help by putting this unfortunate situation in front of the public, since without his aid we could do nothing. To my disbelief and anger he implied that I was seeking publicity for myself. He did, however, contact Dr. Shallock and I have since talked with him. He has promised to do what he possibly can this Spring and I hope his viewpoint has changed concerning my efforts.

Finally we come to the subject of Legislation on the State level.

I spoke to Mr. Peter J. McDonough of Plainfield and Mrs. Mildred Barry Hughes, members of the General Assembly. They were both cordially receptive to the suggestion of Legislation for the Control of Ragweed and requested literature that would serve to enlighten them further on the topic.

To date, I have been informed that Mrs. Hughes has prepared a bill on ragweed. For this much I am grateful but in my estimation it is only a beginning with the end nowhere in sight. It cannot and it must not take years to educate the public or obtain legislation to enforce existing ordinances or funds to carry out such a program. We need assistance starting immediately!

The next step was to contact Senator Stamler who had just returned from his vacation. Senator Stamler listened attentively and I shall sum up his reply as follows:

1. He has rose fever and from a practical viewpoint cannot abolish roses.

2. As a legislator, he feels that it cannot be made unlawful to grow weeds. Please note: The average home is usually well maintained. It is the highways, parkways, parks, empty lots, and railroad sidings that present the real problems. Mr. Peterson of the Dept. of Agriculture informs me that the farmers are among the first to cooperate regarding this problem.

3. The State Board of Health has ample funds with which to set up an efficient spray control program and if a bill is to be forthcoming the Senator suggests it be presented directly by the State Board of Health and not in any case to him for he would more than likely not approve it.

Results? Negative.

With reference to correspondence from Mrs. Elizabeth Cooke, Horticulture Chairman of the Garden Club of N.J. and lay speaker at this conference last year, I quote "as an ardent Conservationist and former State Conservation Chairman, I am not for indiscriminate state wide spraying of anything." I believe this should and can be handled on a supervised, municipal basis."

Comment: A most admiral viewpoint but totally ineffective in communities that will not cooperate.

By this time it must be obvious that we are facing a rather frustrating situation and if I appear disheartened, the truth is that I am. But, more important is the plight of the asmatic, the elderly and the children who are chronic hay fever sufferers. I am sorry to say that I am strictly an amateur at making public speeches but I hope I have made myself clear on their behalf.

My daughter's comments are as follows:

"I DONNA LEE SCHIFFMAN WILL NOT STAND FOR THIS. IT IS NOT FUNNY.

"I HATE RAGWEED. I MUST GO TO THE ALLERGIST FOR TESTS. IT WILL COST 100$ FOR TESTS. OR MAYBE 300$. I DO NOT KNOW.

I SAY GET RID OF RAGWEED. KILL IT DED. THIS IS ALL I HAVE TO SAY. GOOD-BY."

THE END

Mrs. Ray Schiffman
706 Riverbend Drive
Linden, New Jersey

EFFECTS OF SIMAZINE ON AQUATIC PLANTS IN A FARM POND[1]

David L. Sutton, T. O. Evrard, and W. E. Chappell[2]

Introduction

The diversity of algae and higher plants in aquatic environments makes it difficult to evaluate the effects of a given chemical at different concentrations. It has been shown that by using plastic enclosures to form plots within a single pond, a better evaluation of the effects of a chemical on the aquatic plants can be made (Walker, 1959). Such an approach will help to minimize the variables and offer a more homogenous environment for herbicide testing.

The main objective of this study was to evaluate the effects of three concentrations of Simazine on the aquatic plants in plastic enclosures.

Method

Black polyethylene sheeting of 8 mil thickness was used to make seven plastic enclosures in a pond near Blacksburg, Virginia. The plots ranged in size from 0.006 to 0.013 acres. Depths of the plots were from 20 to 37 inches.

Simazine 80W (2-chloro-4,6-bis(ethylamino)-s-triazine) was applied on July 28, 1964. Treatments were as follows:

a. Plots 1 and 5 - 0.5 ppm
b. Plots 2 and 6 - 1.5 ppm
c. Plots 3 and 7 - 3.0 ppm
d. Plots 4 and 8 - controls

Plot 8 was an area in the same pond but outside the plastic container that was used as an additional check.

Aquatic plants observed in this study were *Oedogonium spp.*, *Spirogyra spp.*, *Oscillatoria spp.*, *Chara spp.*, *Potamogeton foliosus*, *Equisetum spp.*, and one non-aquatic Bermudagrass, *Cynodon dactylon*. Cattails, *Typha latifolia* and arrowhead, *Sagittaria latifolia* were transplanted from other areas of the pond into the plots.

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[1] These studies were supported in part by a grant from Geigy Agricultural Company.

[2] Graduate Assistant, Instructor, and Professor of Plant Physiology, respectively, Virginia Agricultural Experiment Station, Virginia Polytechnic Institute, Blacksburg, Virginia.

Oxygen, temperature, and pH readings were taken to help evaluate the effects of Simazine on the aquatic plants. Surface oxygen was measured in ppm with a YSI model 51 Oxygen Meter. Temperature readings were also recorded with this instrument. The oxygen and temperature readings were taken in the top six inches of surface water in approximately the center of the plot. The pH was taken with a Heligae pH comparator using Thymol Blue - B as indicator. Visual estimates of the percent of aquatic plants removed were made for each plot.

Results

All three concentrations of Simazine gave varying degrees of control, as shown in Table I.

Table I. Control of aquatic plants 7 and 28 days after treatment.

Species	7 days						28 days					
	1	2	3	5	6	7*	1	2	3	5	6	7*
Oedogonium	0	9	10	6	9	10	0	9	10	8	9	10
Spirogyra	9	-	-	9	-	-	9	-	-	9	-	9
Oscillatoria	9	-	-	9	9	-	9	-	-	9	9	-
Chara	0	0	0	0	0	0	0	4	10	0	4	10
P. foliosus	0	0	0	0	0	0	0	4	10	0	4	10
Equisetum spp.	-	0	-	-	-	-	-	10	-	-	-	-
Cattails	0	0	0	0	0	0	0	0	0	0	0	0
Arrowhead	0	0	0	0	0	0	0	0	0	0	0	3
Bermudagrass	0	0	0	0	0	0	0	0	0	0	0	0

* Plot Number
0 = no control; 10 = 100% control

The 0.5 ppm concentration in plots 1 and 5 caused a 60 percent decrease in the surface Oedogonium three days after treatment. In plot 1, which had a maximum depth of 20 inches, Oedogonium increased to its original surface amount in seven days. Oedogonium in plot 5, maximum depth of 32 inches, increased to less than half of its original amount in seven days. The cattails and arrowhead more than doubled in number 28 days after treatment. The 0.5 ppm rate did not seem to affect any of the other aquatic plants.

The 1.5 ppm concentration in plots 2 and 6 removed 90 percent of the surface Oedogonium in three days. Traces of this algae could be found during the rest of the study in the two plots. This rate gave about a 40 percent removal of the P. foliosus and Chara by the end of four weeks. The cattails and arrowhead had doubled in number 28 days after treatment. Initially plot 2 had a small growth of Equisetum which disappeared 11 days after treatment.

No Oedogonium was found in the plots 3 and 7, which were treated at the 3.0 ppm concentration, six days after treatment. P. foliosus and Chara were eliminated by the end of four weeks. The cattails doubled in number. The arrowhead plants decreased in number by 30 percent in plot 3 and increased by 20 percent in plot 7.

All of the plots had varying amounts of Bermudagrass extending into the water. This grass species did not seem to be affected by any of the Simazine concentrations.

Spirogyra was found in plots 1 and 5 four days after treatment. In plots 2 and 6 this algae showed up at 7 and 10 days respectively. A trace of Spirogyra was found in plot 7 twenty-seven days after treatment. The Spirogyra never increased to more than several small groups on the bottom of each plot.

Oscillatoria was found in plots 1, 5 and 6 before treatment but was never more than a small floating clump of each plot.

The surface temperature of the water on the day of treatment was 32°C, which was the highest temperature recorded during the study. The temperature varied from 23.0 to 31.5°C during the 24 day period it was measured.

As shown in table 2 less than 0.04 ppm of Simazine was in every plot except number 7 as measured three days after treatment. Plot number 7 had a concentration level of Simazine at 0.05 ppm. Seven days after treatment there was an increase of chemical in the water.

Table II. Chemical analysis for Simazine in ppm at 3 and 7 days after treatment.

Plot Number	7/31	8/4
1	0.04	0.05
2	0.04	0.24
3	0.04	--
5	0.04	0.09
6	0.04	--
7	0.05	--

Table III. Oxygen readings in ppm taken between 1 and 2 p.m.

Plot No.	7/28	7/29	7/30	7/31	8/1	8/4	8/6	8/11	8/14	8/17	8/20
1	10.0	8.0	4.5	5.0	6.0	9.5	11.0	11.5	14.5	15.5	14.5
2	11.5	8.0	3.0	3.0	4.5	7.5	9.0	8.5	12.0	14.0	13.0
3	11.5	7.5	2.0	2.0	4.0	6.0	6.5	6.0	8.5	10.5	10.0
4	11.5	11.5	10.5	10.0	12.0	8.5	11.5	9.5	13.0	13.0	13.5
5	10.5	8.5	4.5	4.5	4.0	8.0	10.5	10.5	13.0	14.0	13.0
6	11.5	8.5	3.0	3.5	3.5	6.5	7.5	8.0	9.5	9.5	9.5
7	10.0	8.0	2.0	1.5	3.0	5.0	6.5	6.0	6.5	5.5	6.0
8	10.5	10.5	10.0	10.5	12.0	8.5	11.0	10.0	10.5	10.0	11.5

Table IV. Heligae pH Comparator readings.

Plot No.	7/28	7/29	7/30	7/31	8/1	8/2	8/4	8/6	8/10	8/14
1	8.5	8.6	8.2	8.2	8.3	8.4	8.4	8.6	9.0	9.0
2	8.6	8.7	8.2	8.2	8.0	8.1	8.2	8.4	8.6	8.8
3	8.6	8.7	8.1	8.1	8.1	8.0	8.0	8.2	8.3	8.5
4	8.6	8.7	8.7	8.6	8.7	8.8	8.7	8.9	8.9	9.0
5	8.6	8.6	8.2	8.2	8.3	8.4	8.4	8.6	8.8	9.0
6	8.6	8.7	8.1	8.2	8.1	8.2	8.2	8.4	8.4	8.6
7	8.6	8.6	8.1	8.0	8.0	7.9	8.0	8.2	8.3	8.4
8	8.5	8.7	8.7	8.7	8.6	8.7	8.6	8.6	8.7	8.8

Discussion

All seven plots were heavily infested with an algal mat of Oedogonium. Three days after treatment most of the algal mats were lying on the bottom of the plots. By the seventh day most of the algae was eliminated in the plots treated at the 1.5 and 3.0 ppm concentration of Simazine. At the lower concentration, 0.5 ppm, the mats started floating in 6 to 7 days. The deeper plot treated at 0.5 ppm showed much more control than the shallow plot. Removal of the aquatic plants took much longer than the algae. There was a gradual decrease in the amount of Chara and P. foliosus. It took about four weeks for complete removal of these aquatic plants at the 3.0 ppm rate.

The number 9 rating given for Spirogyra in Table I is somewhat misleading. Since this species did not increase in numbers to any great extent, it is presumed that it was controlled by the Simazine. This species may have been present before treatment but microscopic examinations of algae samples did not indicate any Spriogyra until after treatment.

Chemical analysis of the water three days after treatment showed a very rapid disappearance of Simazine. Seven days after treatment Simazine was in the water at low concentrations. This seems to indicate a release of Simazine by the decayed vegetation back into the water.

Simazine must have been taken up very rapidly by the aquatic plants. The high water temperature would increase the metabolic rate of the aquatic plants. This increased activity of the aquatic plants may partly account for the rapid disappearance of Simazine. Growth of the algae was stopped very soon after application as evidenced by oxygen readings and visual observations. In the larger plants it took a much longer time for the effect to show up. This seems to indicate that the algae absorbed the Simazine very soon after application, while in the larger aquatic plants Simazine is either absorbed by the plant directly from the water or slowly absorbed through the roots from soil particles containing Simazine.

Table III shows a fairly high level of dissolved oxygen on the treatment date. Two days later there was a reduction of oxygen in the plots treated. Plots treated at the 0.5 ppm rate had a fairly rapid oxygen increase to the

original amount. In the plots of higher Simazine concentration there was a more gradual rise in oxygen present. A gradual decay of aquatics would put a larger oxygen demand on these plots treated at the higher rates. This seems to indicate a gradual removal of the larger aquatic plants as opposed to the sudden inhibition of the growth of the algae. Visual observations showed a gradual decrease of Chara and P. foliosus.

As the amount of oxygen decreased there would be more carbon dioxide in the water. The higher carbon dioxide concentration would tend to increase the amounts of carbonates and bicarbonates which would result in a lowering of the pH. Table IV shows a drop in the pH and then a gradual return to the initial pH.

Conditions in the plots did not seem to be altered by the plastic. Oxygen, temperature, and pH readings of the control plot did not vary too much from that measured outside the plot.

Summary

1. Simazine at the 0.5 ppm concentration did not seem to affect the larger aquatic plants. In the deeper plot this rate removed more than half of the algal mats.

2. Simazine removed the Oedogonium mats at the 1.5 and 3.0 ppm concentrations. The 3.0 ppm concentration controlled the Chara and P. foliosus.

3. Simazine was taken up very rapidly by the algae. It took a much longer period of time for higher plants to be affected by Simazine.

4. There was a decrease in dissolved oxygen two days after treatment.

5. Spirogyra was the first algae to show up after treatment.

Reference

Walker, C. R. 1959. Control of aquatic weeds in Missouri Farm Ponds. Weeds 7(3):310-316.

AQUATIC WEED CONTROL STUDIES IN VIRGINIA FARM PONDS

David L. Sutton, T. O. Evrard, and W. E. Chappell[1]

Introduction

The increasing demand for water in the rural areas has put more emphasis on management of the farm pond. This stored water can be used for irrigation, watering livestock, fire protection, and recreation. Heavy growths of aquatic plants can limit these uses of the water.

A farm pond can be thought of as a small body of water having a maximum surface area of five acres and maximum depth of fifteen feet (Eipper and Brumsted, 1958). The nature of these small bodies of water make them susceptible for heavy growths of aquatic plants. Proper construction helps to reduce the amount of plants. Shallow warm waters and affluent water rich in nutrients provide conditions which produce an abundant growth of aquatic plants. The well-managed farm pond will have need for control of the aquatic plants from time to time.

Objective

This study was concerned with the control of aquatic plants mainly in farm ponds. The chemicals used were those which have either shown promise or are already established aquatic herbicides. Simazine was the chemical under most extensive study. All applications were postemergent treatments.

Methods

Chemicals used in this study were the following: wettable powder and granular forms of Simazine (2-chloro-4,6-bis (ethalamino)-s-triazine); liquid form of Endothal (3,6-endoxo hexohydropthalic acid) plus Silvex (2-(2,4,5-trichlorophenoxy propionic acid); low volatile esters of 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5- trichlorophenoxyacetic acid); and granular dichlobenil (2,6-dichlorobenzonitrile). Chemicals used for ditchbank treatments were mixtures of 2,4,5-T and amitrole (3-amino-1,2,4-triazole); and 2,4,5-T and dalapon (2,2-dichloropropionic acid). The chemicals were applied to the surface by gasoline and hand pumps. The chemical was mixed by churning the water with the boat motor, and dumping chemical without mixing into the water.

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[1] Graduate Research Assistant, Virginia Agriculturla Experiment Station, Blacksburg, Virginia.

[2] Aquathol plus

Aquatic plants treated were pondweeds Potamogeton spp., P. foliosus, P. crispus, coontail (Ceratophyllum demersum), duckweed (Lemna spp.,), white water lily (Nymphaea ordorata), arrowhead (Sagittaria latifolia), spikerush (Eleocharis spp.), cattail (Typha latifolia), and various species of Chara, Spirogyra, Oedogonium, Rhizoclonium, Oscillatoria, Lyngbyea, Anabena, Anacystis, and Closterium.

Results

The results of 29 tests were observed in 21 ponds treated from mid-spring to late summer. Pond sizes varied from 0.1 to 2.5 surface acres. A visual estimate of the amount of aquatic plants controlled was made during periodical visits to the ponds. Chemical analyses of the water were made on those ponds treated with Simazine.[3]

1. Submerged species

Light to heavy growths of Potamogetons was controlled with Simazine at 1.0 to 4.0 ppm. It took about 4 weeks for control of this species. There was a gradual removal of the plant after treatment. In two ponds having heavy growths of Potamogeton, Simazine applied at 3.0 and 4.0 ppm resulted in a fish-kill five days after treatment.

An April application of granular 2,4-D (rate unknown) followed by a May application of Simazine at 2 ppm gave control of a heavy growth of Potamogeton crispus.

Endothal plus silvex at 2 ppm was very effective in removing a light and heavy growth of Potamogetons. This chemical seemed to have little effect on the algae present.

A light growth of coontail was removed by 2,4-D at 15 pounds per acre.

2. Floating species

Duckweed was the only floating species observed in this study. Greenhouse tests with gallon jars showed that Simazine at 1.0 and 2.0 ppm gave fair to good control respectively of duckweed in one month. Simazine at 2.0 ppm controlled this species in two pond tests in 3-4 weeks.

3. Emergent species

White water lily was controlled in two pond tests with 2,4-D at 15 pounds per acre. A mid-May application of 2,4-D and 2,4,5-T at 2 pounds per acre removed twenty percent of a heavy growth of lilies, but regrowth had occurred in two months. A mid-summer application of the same pond with D & T at 15 pounds per acre adequately controlled the plants.

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[3] Water analyses and chemical furnished by Geigy Chemical Corporation.

Simazine at 3 ppm removed several large groups of arrowhead from one pond; the plants had turned completely brown in two weeks.

Spikerush was not considered a weed species in any of the ponds treated. In all ponds treated with Simazine at 1.0 ppm and above this species showed signs of damage several weeks after treatment.

Cattails were not controlled by any of the chemicals used.

4. Algae

Simazine was very effective in the control of algae (Table 1).

Table 1. Simazine treatments of algae in percent control

	Wettable powder, 80 percent						Granular, 4 percent	
Species	0.5	1.0	1.5	2.0	3.0	4.0	3.0	4.0
Spirogyra	100	65	-	80	100	100	100	100
Oedogonium	-	100	100	80	100	-	100	-
Chara	100	65	-	-	100	-	-	100
Rhizoclonium	100	-	100	75	-	100	-	-
Oscillatoria	-	100	100	75	100	-	-	-
Lyngbya	-	-	-	100	-	-	-	-
Anabena	-	-	-	100	-	-	-	-
Anacystis	-	-	-	100	-	-	-	-
No. of Ponds Treated	1	3	1	7	1	1	1	1

Usually within two days after treatment the algae mats were gone from the surface. It would then take a few more days depending on amount of growth for removal from the bottom. Oscillatoria and Chara required the longest time to control. It took about two weeks for control of Oscillatoria. Chara was controlled in about four weeks. Closterium appeared in large numbers on the bottom in several ponds soon after application. However, this species was not considered an objectionable algae growth.

Dichlobenil at 10 pounds per acre was effective in only one test of three in controlling Chara. Simazine at 6.0 ppm was not effective in controlling one pond of Chara because of the large volume of water flowing through it.

5. Ditchbanks

A group of combinations of chemicals were tested on ditchbank plots. The combinations of both 2,4,5-T (4 ounces per gallon) and amitrol (0.48 grams per gallon), and 2,4,5-T (4 ounces per gallon) and dalapon (0.98 grams per gallon) gave good control of the plants.

6. Water analysis

Chemical analyses of the water were made on ponds treated with Simazine. Samples were taken prior to treatment, seven days after treatment, and every month during the growing season. There was a rapid drop in chemical concentration during the first week after application and then a more gradual decline in chemical concentration. There was a faster decrease in chemical concentration in those ponds with effluent water.

Discussion

The aquatic plants found most frequently in the farm ponds studied were Potamogetons, Chara, Spirogyra, and Oedogonium. These aquatic plants occurred in light to heavy growths. Simazine was effective in the control of these aquatic plants and algae responded readily also. Two early spring applications at low concentrations had to be followed up with another application of Simazine. The amount of algae present at the second treatment was greatly reduced as compared to the original amount.

Chemical analysis of the water showed a rapid decline of Simazine soon after application and then a more gradual decrease. Those ponds with a large volume of outflowing water had a more rapid decrease in chemical concentration than those ponds which had little effluent water.

Ponds with heavy growth of the aquatic plants should have several treatments at low concentrations, if the pond has fish in it. During periods of hot weather there may be fish die-offs due to low dissolved oxygen content. The fish die-offs observed in this study are presumed to be due to low dissolved oxygen content.

Water lilies were effectively controlled by low volatile ester of 2,4-D, 2,4,5-T, and D and T mixtures at the rates of 15 pounds per acre. The partial control of this plant species by D and T at 2 pounds per acre seem to indicate that rates of less than 15 pounds per acre may be effective in the control of water lilies.

Conclusion

1. Simazine concentration of 0.5 - 4.0 ppm was effective in the control of Potamogetons, Chara, Spirogyra, and Oedogonium.
2. White water lilies were controlled by 2,4-D and 2,4,5-T at rates of 15 lb/acre.
3. Endothal plus silvex at 2 ppm controlled Potamogetons.
4. Combinations of 2,4,5-T and amitrol, and 2,4,5-T and dalapon were effective in the control of ditchbank plants.

Literature Cited

Eipper, A. W. and A. B. Brumsted, 1958. How to control weeds and algae in farm ponds. Cornell Extension Bulletin 1014. 32 pp.

THE EFFECTS OF CERTAIN HERBICIDES ON THE GROWTH OF

CHLORELLA PYRENOIDOSA 7-11-05

J. S. Wells and W. E. Chappell[1]

The use of microorganisms for bioassay procedures has for some time been a very important means of detecting the presence of vital growth factors in defined media, or chemical inhibitors which might be present in the soil or water. The present work was designed to develop a bioassay procedure for the detection of herbicide residues remaining after periods of time in soil or water previously treated with these chemicals. Therefore, the effect of various purified herbicides on a test organism was determined under optimal growth conditions in the laboratory.

The organism used was a member of the phylum Chlorophyta, Chlorella pyrenoidosa 7-11-05 which has an optimum temperature requirement of 39°C. The tests were carried out with synchronized cells following the procedure of Schmidt (1). Growth was measured turbidimetrically with a Spectronic 20 at 550/mu. Optical density readings were taken every two hours over a period of 14 hours, which corresponds with the approximate life cycle of the organism. The organisms were grown in 38 x 200 mm test tubes placed in a constant temperature (37°C) controlled water bath. Constant lighting was provided by five 40W fluorescent lights placed along both sides of the water bath. Proper atmospheric conditions were established by bubbling 3% CO_2 through the medium.

The herbicides tested were Simazine 80W, Atrazine 80W, Casoron, and 2,4-D (LV-4D). The concentrations ranged from 0.1 to 10 ppm. Simazine 80W and Atrazine 80W at 0.1 ppm were slightly inhibitory. Concentrations above 1 ppm completely inhibited growth of the alga. Wtih Casoron and 2,4-D neither of these chemicals showed the slightest inhibitory effect, even at the highest concentration.

The bioassay described above can be utilized to detect concentrations of Simazine and related Atrazine herbicides at concentrations of 0.1 to 0.5 ppm. Future work will attempt to improve the sensitivity of this method. Since the strain of Chlorella pyrenoidosa used in this work is not a typical inhibitant of ponds and lakes, the use of a more typical algae may produce better results.

The bioassay procedure described by Zweep (2) using barley and rye seeds is said to be sensitive to about 0.2 to 1 ppm of Simazine. The synchronized culture method has an equal or better sensitivity than the seed method, and it can be completed in 14 hours, whereas the seed bioassay may take as long as 12 days.

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Future work will investigate the mode of action of these herbicides on algal inhibition and improving detection procedures of herbicide residues in soil and water.

References

(1) Schmidt, R. R. 1961. Experimental Cell Research 23:209-217.

(2) Zweep, W., Van Der. 1958. Mededel-Landbouw-Hogeschool en Opzoekingssta. Staat Gent. 23:1000-1009.

THE EFFECTS OF SEVERAL ALGAECIDES ON AQUATIC PLANTS

W. V. Audia and W. H. Preston, Jr.[1]

Introduction

There are many different algaecides used to control the growth of algae in swimming pools, aquariums, water cooling equipment, as well as in lakes and ponds. What are the effects of these algaecides on higher aquatic plants? We have answered this question in part by making observations on certain emersed and surface aquatic plants growing in algae-contaminated water treated with different algaecides. This report is concerned only with the effects of some algaecides on such higher aquatic plants.

Materials and Methods

I. Outside Tests: During the summer of 1964 several algaecides were tested at Beltsville, Maryland, to determine their effectiveness in controlling growth of certain species of algae. Concentrations used were those recommended on product labels for control of established algae in swimming pools, ponds, or aquariums. Several higher aquatic plants were allowed to remain in the test ponds to observe any phytotoxic effects of the algaecides on them. These plants included Soft Rush (*Juncus effusus*), Duck Potato (*Sagittaria sinensis*), False Loosestrife (*Ludwigia palustris*), Pepperwort (*Marsilea quadrifolia*), Duckweed (*Lemna minor*), Water Velvet (*Azolla caroliniana*), Floating Moss (*Salvinia rotundifolia*), Water Fern (*Ceratopteris thalictroides*), Water Hyacinth (*Eichhornia crassipes*), and Water Lettuce (*Pistia stratiotes*).

Eight different algaecide treatments were applied to separate outdoor ponds lined with 5-mil transparent polyethylene. The ponds, 5' x 5', contained approximately 281 gallons when filled to a water depth of 18 inches. This depth was maintained by additions of tap water twice a week.

Ponds were filled with water and plants were added on May 26, 1964. The emersed plants (Soft Rush, Duck Potato, False Loosestrife, and Pepperwort) were in pots of soil submersed just below the water surface. All other plants floated freely on the water. By June 1, 1964, water in all the ponds was dark green due to growth of algae, and the higher aquatic plants were growing rapidly. The algaecides added to the ponds on June 3, 1964, included: calcium hypochlorite, potassium chlorate, dichlone, copper sulfate, phenylmercuric acetate, n-alkyl (40% C_{12}, 50% C_{14}, 10% C_{16}) dimethylbenzylammonium chloride, and a mixture of 4 quaternary compounds: alkenyl (90% C_{18}, 10% C_{16}) dimethylethylammonium bromide, n-alkyl (C_{14}, C_{16}, C_{12}, C_{18}) dimethylbenzylammonium chlorides, n-alkyl (C_{12}, C_{14}, C_{16}, C_{18}) dimethylethylbenzylammonium chlorides, and n-alkyl (C_{12}, C_{14}) dimethyl-1-naphthylmethylammonium chlorides. (See Table 1 for amounts used.) Six, 13, and 15 days after the initial treatments, the responses of the plants were rated as follows:

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[1]Plant Physiologists, Pesticides Regulation Division, Agricultural Research Service, U. S. Dept. of Agriculture, Beltsville, Maryland.

"0" - no effect (same as untreated);
"1" to "4" - intermediate levels of phytotoxicity;
"5" - plants appear dead;
"-1", "-2" - treated plants appeared to grow better than untreated.

II. Greenhouse Tests: During the fall of 1964, 15 algaecides were tested for phytotoxicity to Water Velvet under greenhouse conditions. These algaecides are listed in Table 2 along with the treatment rates.

Shallow 6" x 10" pyrex dishes were filled with 1-liter portions of tap water (1" depth), and approximately 0.25 g fresh weight of Water Velvet plants were then added to each dish. Soluble fertilizer (20-20-20) was added at the rate of 1 g to each dish at this time and at 4 and 14 days later. The Water Velvet was grown in the dishes for 3 days. On October 26, the algaecides were added at the initial dosage rates, with maintenance doses added according to product label recommendations for algae control in pools, ponds, or aquariums.

The treatments were arranged at random in each of three replicated blocks. Throughout the test the dishes remained on a white-painted wooden stand. The plants were exposed to 2-hour light interruptions beginning at midnight. Ten and 18 days after the treatments were begun, the responses of the plants were rated as described for the outdoor tests.

Results

I. Outside Tests: Ratings of plant injury by the treatments are given in Table 1. Calcium hypochlorite and potassium chlorate caused no apparent injury or inhibition of the higher aquatic plants used in this test; in fact, some of these plants appeared to grow better than those in untreated ponds. Phenylmercuric acetate and copper sulfate were phytotoxic to most floating plants, but caused very little detrimental effect on plants established in soil.

Treatments with the quaternary compounds were moderately phytotoxic to Water Hyacinth and killed all other plants except Soft Rush and Duck Potato.

II. Greenhouse Tests: Table 2 shows the relative phytotoxicity of 15 algaecides which were tested on Water Velvet. Treatments with dichlone, calcium hypochlorite, potassium chlorate, potassium dichloroisocyanurate, and sodium pentachlorophenate with 2-mercaptobenzothiazole resulted in no apparent detrimental effect to the Water Velvet which, like the controls, appeared healthy with dark green top growth and good root growth. Within 10 days after initial treatment with copper nitrilochelate, test plants were observed to develop slightly less top and root growth than controls, but this difference was not apparent 18 days after initial treatment.

Treatments with the quaternary compounds (J, K, L, M, N, and O in Table 2) and copper sulfate caused older foliage to turn orange and brown. The younger top growth was lighter green and noticeably less abundant than that of untreated plants. Many of the older roots dropped from the plants and new root growth was very limited.

The mixture of monuron, simazine, atrazine, and dichlone caused the Water Velvet plants to fragment into very small segments. Many plant fragments were dark brown in color and appeared dead. Almost no new top or root growth was observed.

Plants treated with phenylmercuric acetate had little top and root growth. Approximately 50% of the top growth was very dark brown and appeared dead.

Summary

Several algaecides were supplied to outdoor ponds containing aquatic plants at Beltsville, Maryland, during the summer of 1964. Calcium hypochlorite, dichlone, and potassium chlorate caused no apparent phytotoxic effects on Soft Rush, Duck Potato, False Loosestrife, Pepperwort, Duckweed, Water Velvet, Floating Moss, Water Fern, Water Hyacinth, and Water Lettuce; some of the plants grew better than those in untreated ponds. An alkyl benzyldimethylammonium chloride and a mixture of 4 quaternary ammonium compounds were moderately phytotoxic to Water Hyacinth and killed all other plants except Soft Rush and Duck Potato. Phenylmercuric acetate and copper sulfate damaged most of the floating plants, but not those established in soil (Soft Rush, Duck Potato, False Loosestrife, and Pepperwort).

Fifteen algaecides were tested under greenhouse conditions on Water Velvet (*Azolla caroliniana*). Within 18 days, 6 quaternary ammonium treatments, copper sulfate, phenylmercuric acetate, and a mixture of monuron, simazine, atrazine, and dichlone caused moderate to marked inhibition of growth of Water Velvet. Copper nitrilochelate caused slight reduction of growth. Dichlone, calcium hypochlorite, potassium chlorate, potassium dichloroisocyanurate, and a mixture of tech. sodium pentachlorophenate with 2-mercaptobenzothiazole caused no apparent injury or growth inhibition.

Table 1. Responses* of aquatic plants to 8 algaecide treatments supplied to 281-gal. outdoor ponds beginning 6/3/64.

Aquatic plants	Calcium hypochlorite: Initial tr.: 5.68 g; maintenance: 1.48 g daily			Potassium chlorate: Initial tr.: 0.21 g; no additional dose			Dichlone: Initial tr.: 0.09 g; repeated in 2 and 8 days			Dichlone + Ca hypochlorite: Initial and in 7 days: 0.0[illegible] g of Dichlone; daily: 1.48 g of Ca hypochlorite		
	Days after init.tr. 6	13	15	Days after init.tr. 6	13	15	Days after init.tr. 6	13	15	Days after initial treatmen[illegible] 6	13	15
Soft Rush	1	0	0	0	0	0	1	1	1	1	0	0
Duck Potato	-	-	-	-	-	-	0	0	0	0	0	0
False Loosestrife	0	0	0	0	0	-1	0	1	0	0	0	1
Pepperwort	0	-2	0	0	0	-1	0	0	0	0	0	0
Duckweed	0	-2	-1	0	-1	-1	0	0	0	0	0	0
Water Velvet	0	-1	-2	0	-2	-1	0	0	0	1	-1	0
Floating Moss	0	0	-2	0	-2	-1	0	1	0	1	0	0
Water Fern	0	0	0	-	-	-	2	0	3	-	-	-
Water Hyacinth	0	0	0	0	1	0	1	1	3	0	0	0
Water Lettuce	0	0	0	0	0	0	0	0	0	0	0	0

	Phenylmercuric acetate: Initial tr.: 0.31 g; 6/6: 0.08 g; 6/11: 0.04g			Copper sulfate (pentahydrate): Initial tr.: 2.13 g; repeated 6/11			Alkyldimethylbenzylammonium chloride: Initial tr.: 10.64 g; 6/11: 2.13 g			Mixture of 4 quaternary ammonium compounds (see tex[illegible]: Initial tr.: 2.13 g; repeated 6/4; 0.53 g on 6/8		
	Days after init. tr. 6	13	15	Days after init.tr. 6	13	15	Days after init. tr. 6	13	15	Days after initial treatmen[illegible] 6	13	15
Soft Rush	1	0	1	1	1	1	0	0	1	1	0	1
Duck Potato	0	0	0	-	-	-	0	0	1	●	0	●
False Loosestrife	1	0	3	0	0	0	4	5	5	4	5	5
Pepperwort	1	0	0	1	0	0	3	4.5	5	2	5	5
Duckweed	5	5	5	0	5	5	5	5	5	4	5	5
Water Velvet	4	4	4.5	3	3	4	3	4.5	5	1	4	5
Floating Moss	4	4.5	4.5	0	0.5	0	3	5	5	2	4	5
Water Fern	5	5	5	5	4.5	5	5	4.5	5	3	1	5
Water Hyacinth	3	1	3	0	1	2.5	1	2	3	●	2	3
Water Lettuce	2	1	4	0	1	3.5	1	5	5	1	4	5

*Phytotoxicity ratings: "0" = none; "5" = appear dead; "-1", "-2" = better growth than controls.

Table 2. Responses of Water Velvet to 15 algaecides applied to 1-liter cultures in the greenhouse.

Algaecides	Application Rates (mg/l)		Phytotoxicity ratings*	
	Initial Treatment	Additional Treatments	Days after Initial Treatment	
			10	18
A. Dichlone (2,3-dichloro-1,4-naphthoquinone)	0.08	None	0.3	1.0
B. Calcium hypochlorite	0.0054	0.0011 daily	0.2	00.2
C. Potassium chlorate	0.72	None	0.3	0.8
D. Potassium dichloroisocyanurate (at 0.1 of label dose)	0.0015	0.0015	-0.1	0.2
E. Tech. sodium pentachlorophenate; 2-mercaptobenzothiazole (ratio 29:2)	0.02 total	Repeated 11, 14 & 18 days later	-0.2	0.3
F. Copper nitrilochelate	0.70	Repeated 14 days later	1.0	0.8
G. Copper sulfate (pentahydrate)	2.00	None	2.9	4.3
H. Monuron; simazine; atrazine; dichlone (ratio 15:11:4:2)	0.80	None	4.1	4.8
I. Phenylmercuric acetate	0.16	0.04 (7,11,14 & 18 days later)	4.3	4.4
J. Cetylpicolinium bromide	1.50	0.38 (7,11,14 & 18 days later)	3.1	3.9
K. Alkenyldimethylethylammonium bromide	1.80	0.73 (7 & 14 days later)	2.7	4.0
L. n-Alkyl (40% C_{12}, 50% C_{14}, 10% C_{16}) dimethylbenzylammonium chloride	2.20	Repeated 7 & 14 days later	2.6	4.3
M. Dodecylamine hydrochloride; trimethyl alkyl ammonium chloride; methyl alkyl dipolyoxypropylene ammonium methyl sulfate (ratio 1:1:1)	1.08 total	0.27 (7,11,14, & 18 days later)	2.4	2.8
N. n-Alkyl (60% C_{14}, 30% C_{16}, 5% C_{12}, 5% C_{18}) dimethylbenzylammonium chlorides; n-alkyl (50% C_{12}, 30% C_{14}, 17% C_{16}, 3% C_{18}) dimethylethylbenzylammonium chlorides (ratio 1:1)	2.00 total	0.50 (7 & 14 days later)	3.0	4.2
O. Alkenyl (90% C_{18}, 10% C_{16}) dimethylethylammonium bromide; n-alkyl (C_{14}, C_{16}, C_{12}, C_{18}) dimethylbenzylammonium chlorides; n-alkyl (C_{12}, C_{14}, C_{16}, C_{18}) dimethylethylbenzylammonium chlorides; n-alkyl (C_{12}, C_{14}) dimethyl 1-naphthylmethylammonium chlorides (ratio not known)	2.00 total	0.50 (7 & 14 days later)	2.9	3.9

*Phytotoxicity ratings: "0" = none; "5" = appear dead; "-0.1", "-0.2" = better growth than control. Figures underlined significantly different (at 1% level) from control, as determined by Duncan multiple-range test.

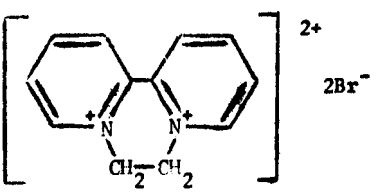
DIQUAT, ITS ACTION AND USEFULNESS AS AN AQUATIC HERBICIDE

JOHN W. MACKENZIE[1]

Diquat 6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrazidiinium dibromide has already proven itself to be a useful aquatic herbicide in many parts of the U.S.A. Extensive trials have been conducted on many different aquatic weed species. By comparison, little work has been published to date on the physiological aspects of Diquat in the control of aquatic plants.

To fully understand the activity of Diquat on plants it is necessary to study closely the properties of this interesting chemical. Diquat is water-soluble and non-volatile. The diagrammatic structure for a molecule of Diquat suggests that it possesses a planar or "flat" nature.

Figure I



This apparent planarity is real and accounts for the stabilization of the active part of the Diquat molecule. Unless the radical possessed this stability, the reduced form would be useless from a phytotoxic standpoint. This reduced radical is the Diquat cation less one electron. Because the active radical is derived from the cation, Diquat treatments are specified in amounts of cation per unit area.

Preliminary trials with Diquat showed that rapid control of many terrestrial plants could be accomplished using low rates of this herbicide. None of the abnormal growth responses induced by phenoxy-type herbicides were observed. Diquat was shown to possess a contact action on vegetation. The first observable symptom of Diquat action is wilting of the foliage, followed by a general collapse of the aerial portions of the plant. Where more resistant plants such as the grasses are treated, a temporary chlorosis may be observed. Well-rooted perennial plants may show regrowth following top-kill by Diquat application.

When the nature of the aquatic environment is considered, it can be seen that the application of a rapidly-diffusing, water-soluble herbicide such as Diquat onto an aquatic weed is simple. The plant is surrounded by its medium of growth, water, and the

1. Technical Specialist, Herbicides, California Chemical Company, Ortho Division, Richmond, California

herbicidal agent is readily dispersed throughout this same medium. Problems of covering the foliage usually do not exist as the chemical completely surrounds the plant. Diquat, therefore, surrounds each plant in the treated area. Depositions of algae or particulate matter can interfere with Diquat's action on any one plant by tying up the cation. Clay particles suspended in the water will deactivate Diquat in a manner similar to that by which the chemical is immediately tied-up on soil.

Differences exist between varieties and species as to whether Diquat acts just as a "burning-back" agent or whether it acts as a complete control agent. Control of Bladderwort (Utricularia spp.) shows Diquat acting as a means of complete control. The foliage and bladders break down rapidly after Diquat application. A more gradual destruction of stem tissue completes control of Bladderwort. The filamentous algae, Chara (Chara spp.), is unaffected by regular Diquat treatments. Rooted emergent plants such as white water lily (Nymphaea tuberosa) and Spatterdock (Nuphar advena) are not completely controlled by Diquat. Burn-back of the foliar parts is accomplished readily but the root portions are unaffected as is seen with perennial weeds on hand. The reasons for such differences may be speculated upon but, as yet, no definitive research has been undertaken. Here indeed is uncharted territory for the research worker to explore.

The movement of Diquat in both an emersed and a submersed aquatic plant has been studied by Lawrence and Funderburk. Shoots of Waterstargrass (Heteranthera dubia) showed no effect when labeled Diquat was applied to their roots but treated shoots were almost completely chlorotic at the end of the treatment. Yet, with the emergent Alligatorweed (Alternanthera philoxeroides) plant, Diquat was translocated from the roots to the shoots, concentrating in the stems rather than the leaves.

Whatever differences exist in Diquat susceptibility from species to species in the aquatic plant world, sufficient research has been carried out on the means by which Diquat exerts its phytotoxic effects to give the following brief description:

Chlorosis occurs not only in terrestrial plants but also in aquatic plants after treatment with Diquat. Duckweed (Lemna spp.) exhibits this characteristic at extremely low concentrations of the chemical. This initial step in the activity of Diquat sets in motion further changes resulting in the complete collapse of the plant. Modern knowledge of the process of photosynthesis have given an insight into this sequence of events. An essential part of photosynthesis is the cycling of electrons. In the course of interfering with this cycling process, the

Diquat cation becomes the reduced radical form. Loss of electrons to Diquat present at these sites results in eventual destruction of the chloroplasts as the "holes" left by departing electrons are no longer refilled. Further results of this interference have not been clearly elucidated but it is believed that a series of complex chemical reactions are set in motion within the cell resulting in cell destruction and eventually that of the whole plant.

The reduced Diquat, having collected its electron, is reoxidized by molecular oxygen back to the original cation and is available once more for herbicidal action. Thus a small amount of Diquat, once arrived at the site of action, can exert a considerable effect through reuse. It is also known that upon decomposition of a Diquat-treated plant, the tied-up Diquat is again available for uptake by untreated plants. This phenomenon is thought to account for the longer period of time required by Diquat for the control of dense infestations of susceptible aquatic weeds.

This review of the mode of action of Diquat as an aquatic herbicide points out several gaps in our knowledge of these processes which have yet to be filled. Practical aspects of Diquat usage in the field have progressed satisfactorily. J. P. Goode reported last year at this conference on use of Diquat in the Northeast region using a standard recommendation of 2 to 4 lbs. cation Diquat per surface acre. The confidence achieved in these trials has been expanded into commercial success during 1964. Other regions of the U.S.A. have utilized this technique with success. In Oregon and Washington, 3 lbs. of Diquat cation has controlled Elodea (Elodea sp.) and Watermilfoil (Myriophyllum spp.) from recreational lakes treated in 1964. In Illinois, Dr. Robert Hiltebran has reported complete control of Slender Naiad (Najas flexilis) and Sago Pondweed (Potamogeton pectinatus) at 2 lbs. Diquat cation per surface acre. In the whole area of the Midwest, acceptance of the "surface acre" treatment has been excellent. Results have been commercially acceptable throughout this area. In the Southeast, Duckweed control has been achieved using 4 lbs. of cation per surface acre as a spray-on treatment. In Florida, where Blackburn and Weldon have carried out a great deal of the development work with Diquat, the use of Diquat as an aquatic herbicide has been established, especially on Watterlettuce (Pistia stratioites), Naiad (Najas spp.), Coontail (Ceratophyllum demersum) and Pondweed (Potamogeton spp.). In California, treatments of Coontail at 4 lbs. cation per surface acre on a trial basis have shown the way to large-scale use on a recreational lake in the Southern part of the state.

It can be said that the "surface acre" concept of Diquat use for aquatic weed control has become widely accepted in 1964. Granular forms of Diquat are now available for experimental work in 1965. These granules were not fully tested during 1964 owing to Hurricanes in Florida and unforeseen circumstances in California. Therefore, there are no results to report at this time.

A 1 to 1 combination of Diquat with Copper Sulfate will also be available for testing in 1965 for increased algae control. If any one object has been achieved by this paper, I trust that it is an awareness that Diquat is a general aquatic herbicide whose potential is now being realized. If, in addition, further work on how Diquat acts is stimulated by this contribution, then I will indeed be satisfied.

THE EFFECT OF pH, AERATION, CALCIUM AND OSMOTIC PRESSURE ON THE GROWTH OF FANWORT (*Cabomba caroliniana*, Gray)

Donald N. Riemer[1]

Four experiments were conducted on the growth of fanwort cuttings in the laboratory. The objectives of the experiments were to determine the effects of various environmental conditions on the plants and to develop techniques for growing fanwort in solution culture.

All of the plants were grown on benches in an air-conditioned laboratory. Lighting was supplied by fluorescent tubes, with a photoperiod of 14 hours per day.

Experiment 1

This experiment was designed to find a suitable pH for growing fanwort. Three cuttings of *Cabomba* (10 cm. long) were planted in each of four 10 gallon aquaria containing 2 inches of washed sand on the bottom and filled with tap water. Two grams of 7-6-19 aquarium fertilizer were dissolved in each one. The pH of this dilute solution was 8.0 and one aquarium was allowed to remain at that value. The pH levels of the other three aquaria were adjusted to 7.0, 6.0 and 4.5, respectively.

The pH of the solution and the length of the above-sand portion of the plants was recorded at intervals during the next 35 days.

At the end of the experiment the plants grown at pH 6.0 were healthy and robust in appearance and had developed extensive root systems. The plants grown at pH 4.5 and 7.0 were slightly smaller, had less extensive root systems, and were paler in color than the 6.0 plants. The plants grown at pH 8.0 became defoliated except for a few leaves at the terminal end of the stem. They grew very little and did not develop any roots at all. Figure 1 shows the average increase in length of the above-sand portions of the three plants at each of the four pH levels. Two conclusions can be drawn from this graph. First, the most growth and fastest rate of growth were exhibited by the plants grown in the solution whose initial pH was 6.0. Secondly, growth of all plants ceased after approximately 8 days. The two most likely reasons for this cessation of growth were that one of the mineral elements in the solution became limiting, or that gasseous exchange between the atmosphere and the solution was not rapid enough and carbon dioxide

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[1]Instructor in Aquatic Weed Control, Soils and Crops Department,

(or possibly oxygen) became limiting. Experiment 2 was conducted to find out if better growth could be achieved by aerating the solutions constantly and thereby increasing the rate of gasseous exchange.

Experiment 2

In this experiment, fanwort cuttings (14 cm. long) were grown in a dilute nutrient solution with and without aeration. The composition of the solution was:

Salt	Concentration
$Ca(NO_3)_2$	.001 Molar
K_2SO_4	.0005 Molar
$MgSO_4$	.0005 Molar
KH_2PO_4	.0002 Molar

plus standard trace element concentrations[1]

The pH of this solution was 5.5 and it was allowed to remain at that value. Every 4 days, one half of the nutrient solution was siphoned out of each of the six experimental vessels and replaced with fresh solution.

At the end of the 30-day growing period the aerated plants were darker green than the unaerated plants and they also appeared to be "stockier" or bushier.

There were pronounced differences in the growth of algae between the aerated and unaerated containers. Algae appeared much earlier in the aerated containers and took the form of a dark blackish-green covering on the sand, air hose, and glass. Algae did not become abundant until 10 days later in the unaerated containers where it took the form of a "bloom" of planktonic species. Eventually a heavy scum of algae formed on the surface of the unaerated water which undoubtedly reduced gasseous exchange with the atmosphere even further. No such scum formed in the aerated containers.

Figure 2 shows the average increase in length of the above-sand portions of the plants grown under aerated and non-aerated conditions. This graph shows a consistent trend for the aerated plants to grow more rapidly than the unaerated plants. It also shows a tendency for the growth of the unaerated plants to level off after a period of time (about 16 days in this case). The aerated plants show no leveling off and the curve continues to climb for the duration of the experiment.

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[1]Standard trace element concentrations: 0.50 ppm Fe; 0.10 ppm B; 0.25 ppm Mn; 0.32 ppm Cl; 0.10 ppm Zn; 0.01 ppm Cu; 0.01 ppm Mo;

The question arises, why didn't the unaerated curve level off completely as did all four curves in Figure 1? This can probably be attributed to the fact that in Experiment 1, the water was not agitated in any way after the cuttings had been planted. In Experiment 2, the water was agitated every 4 days, even in the unaerated containers, during the replacement of half of the solution. This agitation undoubtedly served to increase gasseous exchange and helped to prevent a complete cessation of growth.

As a result of this experiment, continuous aeration was supplied to all of the vessels in the succeeding experiments.

Experiment 3

It was observed that in New Jersey, fanwort is most abundant in areas of soft, acid waters. This experiment was conducted to determine the effects of four calcium ion concentrations (hardness) on the growth of fanwort with pH being held constant.

Cuttings which were 12 cm. long were placed in wide mouth gallon jars containing 600 cc of washed sand and 3 liters of the following nutrient solution:

Salt	Concentration
KNO_3	0.001 Molar
KH_2PO_4	0.0002 Molar
$MgSO_4$	0.0005 Molar
$NaNO_3$	0.001 Molar
$CaCl_2$	0.01, 0.001, 0.0001 or 0.0 Molar

plus standard trace element concentrations

The actual calcium ion concentrations and the calculated osmotic pressures with the four different $CaCl_2$ levels were:

	$CaCl_2$ Concentration			
	0.01 M	0.001 M	0.0001 M	0.0 M
Ca^+ concentration	400.8 ppm	40.08 ppm	4.008 ppm	0.0 ppm
calculated osmotic press.	0.860 Atm.	0.217 Atm.	0.149 Atm.	0.142 Atm.

Each treatment was replicated three times for a total of 12 experimental vessels. The pH of the nutrient solution was adjusted to 5.5. Every 4 days, one half of the nutrient solution in each jar was replaced as in the previous experiment. If the pH after replacement was below 5.3 or above 5.7 it was readjusted to 5.5.

The differences in the general appearance of the plants in this experiment did not appear as early as they did in the first two experiments. Sixteen days after the experiment began, the plants grown with 0.0001 M $CaCl_2$ were longer and had the leaves bent in at a closer angle to the stem than the other plants. Four days later this appearance was more pronounced and the plants growing with no calcium were beginning to show some chlorosis at the terminal end. At the termination of the experiment (36 days from its start), the plants grown with no calcium exhibited typical calcium deficiency symptoms. Chlorosis around the growing point was very pronounced and the terminal leaves were stunted and deformed with brown tips.

Plants growing at the highest $CaCl_2$ level (0.01 M) were pale in color and the stems and leaves were quite flaccid. The leaves became detached from the stem at a slight touch. The plants grown at the two intermediate levels were more nearly normal in appearance but those grown at 0.0001 M $CaCl_2$ were far more vigorous than those grown at 0.001 M $CaCl_2$.

Figure 3 shows the average increase in length of the above-sand portion of the plants. It should be noted that the best growth was exhibited by those plants receiving 0.0001 M $CaCl_2$. It should also be noted that the tendency for the curves to level off does not appear except for the highest $CaCl_2$ level where the plants were apparently dying.

By all four criteria of growth used (rate of elongation, final length achieved, weight of plants, and weight of roots), the plants grown at the 0.0001 M $CaCl_2$ concentration showed the best growth. At the highest $CaCl_2$ level, growth was seriously inhibited and no roots developed at all.

At the termination of the experiment a calcium analysis was made of the plant tissues with the following results:

Calculated Ca^+ concentration in nutrient solution	Ca^+ concentration in plants (fresh wt.)	% calcium in plants (dry wt.)
0.0 ppm	134 ppm	0.243 %
4.008 ppm	218 ppm	0.331 %
40.08 ppm	202 ppm	0.332 %
400.8 ppm	339 ppm	0.611 %

Experiment 4

This experiment was conducted in order to find out how the osmotic pressure of the medium affects the growth of fanwort. In the previous experiments, the solutions used were very dilute compared with the solutions normally used for growing terrestrial plants in solution culture. In this experiment the osmotic pressure was varied by varying the total amount of salt in the solution.

The three solutions used were:

Salt	Sol. #1 Low O. P.	Sol. #2 Med. O. P.	Sol. #3 High O. P.
KNO_3	.001 M	.004 M	.008 M
KH_2PO_4	.0002 M	.0008 M	.0016 M
$MgSO_4$	.0005 M	.002 M	.004 M
$NaNO_3$	.001 M	.004 M	.008 M
$CaCl_2$	.0001 M	.0004 M	.0008 M
Trace elements	standard	standard	standard
O. P.	0.149 Atm.	0.578 Atm.	1.129 Atm.

Cuttings which were 18 cm long were grown in wide mouth gallon jars with 3 liters of solution and constant aeration as described in Experiment 3. One half of the solution was changed every 4 days and the pH was maintained at 5.5. Each treatment was replicated three times for a total of nine experimental vessels.

At the end of the 30-day growing period, dense masses of filamentous algae had formed around the high O. P. plants. Less algae had grown around the medium O. P. plants and far less had formed around the low O. P. plants. Because this algae was entwined in the leaves of the fanwort and could not be removed quantitatively, no meaningful weights could be obtained for the cuttings. The average increases in length at the end of the experiment were: Low O. P. - 58.7 mm; Medium O. P. - 26.7 mm; High O. P. - 8.3 mm. No differences were noted in the external appearance of the plants.

Summary

1. Fanwort cuttings grew better at a pH of 6.0 than they did at pH values of 4.5, 7.0 or 8.0.

2. Fanwort cuttings grew better in aerated containers than they did in unaerated containers.

3. Fanwort cuttings grew better in a solution containing 0.0001 molar $CaCl_2$ than they did in solutions containing 0.0, 0.001, or 0.01 molar $CaCl_2$.

4. Fanwort cuttings grew better in a solution whose osmotic pressure was 0.149 atmospheres than in solutions whose osmotic pressures were 0.578 or 1.129 atmospheres.

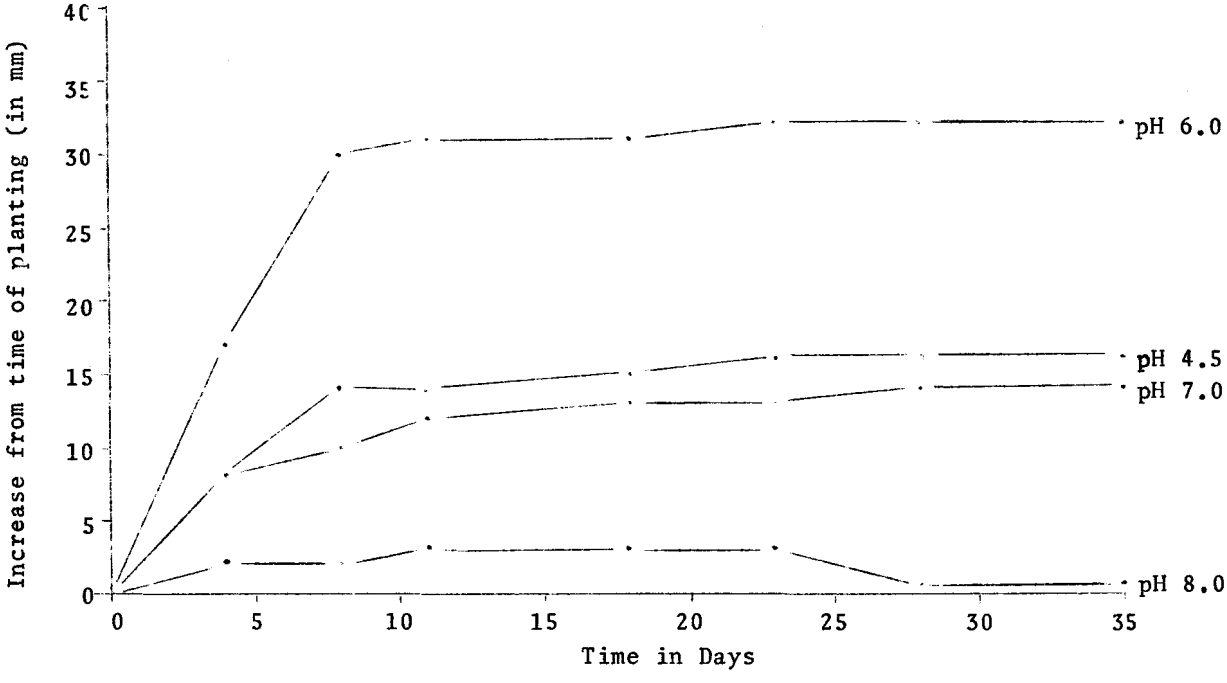

Figure 1. Average elongation of plants at each of the four pH levels.

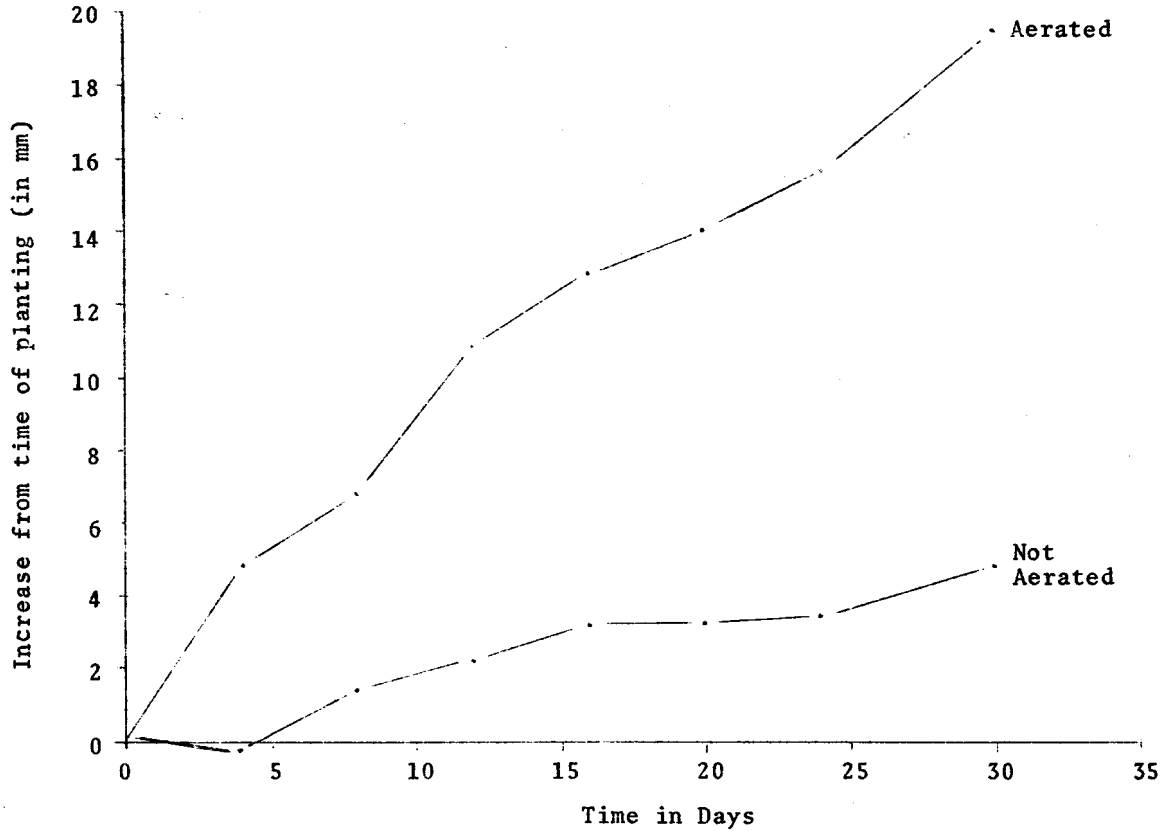

Figure 2. Average elongation of plants in aerated and unaerated containers.

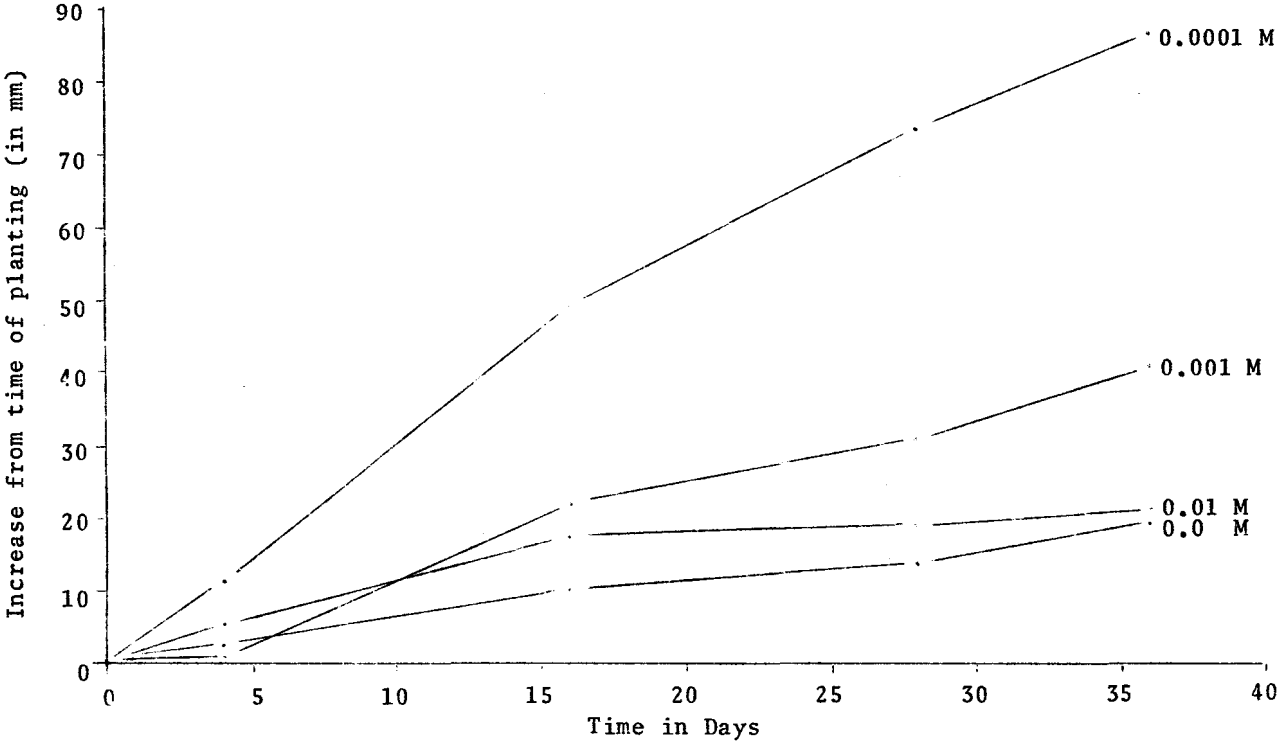

Figure 3. Average elongation of plants at each of the four $CaCl_2$ levels.

AN AQUATIC APPLICATION SERVICE

Roy R. Younger[1]

Since 1924, when the first lake was treated commercially with a herbicide, the chemical industry has been endeavoring to estimate the size and magnitude of the aquatic market. The question of how much money a lake and pond owner is willing to spend to rid his body of water of noxious vegetation has been asked repeatedly by the industry. Countless dollars and man hours have been spent testing compounds to determine their effectiveness, toxicity, and residue. After screening and labeling, the success of a compound rests in the hands of the lake and pond owner. The lake and pond owner refers the types of questions - what type of vegetation, what chemical and how much of it do I use, and how much will it cost - to state and local government extension services. Next the lake and pond owner must file with his state health or fish and game offices for permission to use an aquatic herbicide. Upon receipt of an application permit form, the owner is confronted with additional problems - pond measurements and watershed jurisdictions. At this point, many owners have reached the conclusion that possibly it might pay them to hire someone to handle all phases of the job.

To assist lake and pond owners, the Pennsalt Chemical Corporation organized its Aquatic Applicating Service in December of 1963. The reasons for creating the Applicating Service were: to provide aquatic weed control that was not only successful, but reasonable in cost; and to assist lake and pond owners in all phases of lake and pond management. Realizing that the Service would have to reflect the chemical industry's attitude, meetings were held with the various manufacturers of aquatic herbicides to determine their feelings towards such an organization. The reaction was very favorable.

The area to be covered by the Service was the Mid-Atlantic States: Maryland, Delaware, Pennsylvania, New York, New Jersey, and Connecticut. The various state agencies and water commissions in this area were informed of the Service and its functions. The Service stressed that on any aquatic weed control project the best material available would be used and properly applied, and also, if the material failed to achieve the desired effects, the lake would be retreated at no additional expense to the owner.

There are no Dunn & Bradstreet reports available for lake associations; therefore, the work had to be contracted on good faith. However, the Service provided each lake association with an agreement which, in actuality, was authorization from the lake association to proceed with the program. Included in this agreement were the type and kind of vegetation to be controlled and the areas of the lake to be treated with a specific rate of application of a named herbicide.

To facilitate application, in addition to Service-owned boats, helicopters were rented from New Jersey Helicopter Airways, Trenton, New Jersey.

1. Aquatic Biologist, Pennsalt Chemical Corporation

These helicopters were outfitted with either liquid or granular dispersing equipment, depending on the type of material to be utilized.

The Service had to meet all state and local government agency requirements, either by filing for permission to treat or by being licensed to operate in that state. In the area in which the Service was equipped to work, five states required permits and one state required licensing.

In 1964, the Aquatic Applicating Service was active in four states: New Jersey, Pennsylvania, Maryland, and Connecticut. All the aquatic herbicides available on the market were used on some project. As a rule, these materials produced the desired results; however, there were two instances in which retreatment was necessary.

After reviewing this past year's activities, it is felt that some definite conclusions can be made with regard to the performance and acceptance of the Aquatic Applicating Service. In general, the public acceptance of the Service exceeded our expectations. Many associations were referred to us by friends made while treating other lakes. With regard to performance, all the materials seemed to function as required. In using the helicopter, we had no difficulty in applying either type of material, granular or liquid. There was no shoreline damage from applying liquid materials, which not only speaks highly of the use of the helicopter as a tool for aquatic application, but also of the materials, whose dust or volitility might have caused some damage. When the Service was organized, rumbles were heard that the Service would affect other commercial applicators. We feel that we did not interfere with the services provided by others. It must be remembered that commercial applicators do not, in general, have the equipment capable of doing larger acreages. We are convinced that the need for our Service has been established, and we look forward to the challenge of the future.

PERFORMANCE OF EXPERIMENTAL HERBICIDES APPLIED PRE-EMERGENCE FOR CRABGRASS CONTROL IN TURF

Ralph E. Engel and Richard D. Ilnicki[1]

Additional new chemicals have shown promise for crabgrass control in turf the past several years. Calcium arsenate and chlordane found use in previous years; while DCPA and DMPA have found recent use. A number of newer chemicals have appeared the past two or three years. The purpose of this study was to compare and evaluate these chemicals for crabgrass control and safety to the turfgrasses.

Methods

Azak, bandane, Betasan, Tupersan, AC-9180, El-110, TOK, UC-22463, and V-21944 were evaluated along with DCPA and DMPA for pre-emergence crabgrass control on Kentucky bluegrass lawn turf. All chemicals were applied April 1, April 23, and/or May 15. A randomized complete block design with three replications was established. Cool weather in April and the first week of May along with dry weather that followed prevented significant crabgrass germination until mid-July. Crabgrass estimates were made October 3, 1964 when cool weather checked crabgrass growth.

The same group of chemicals were applied to 3/4-inch bentgrass turf on May 27, 1964, at established rates and 2X rates. Injury ratings were made in August and September of 1964.

Results

The crabgrass control ratings for Azak, Betasan, DCPA and DMPA applied on April 1 were 80, 98, 94 and 73%, respectively (Table 1). When Azak was applied on April 23 and May 15, its control ratings increased to 98 and 100%, respectively.

Bandane applied April 1 at 30, 45 and 60 lb/A gave 32, 55 and 83% crabgrass control. This agrees with previous results at New Brunswick which showed the 30 to 45 lb/A range gives only fair control.

Among the newer materials, Tupersan, V-21944, and El-110 showed ability to control crabgrass (Table 2). Tupersan at 12 and 16 lb/A as a dry application and El-110 at 6 lb. as a dry application gave 92, 97 and 97% control. Water spray applications of these two chemicals gave no crabgrass control.

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[1]Professor in Turfgrass Management and Research Specialist in Weed Control, Department of Soils and Crops, Rutgers - The State University, New Jersey Agricultural Experiment Station, New

Table 1. Crabgrass control from previously tested pre-emergence herbicides on lawn turf, 1964.

Chemical	Rate, lb/A	Crabgrass Control (%)
Bandane	30	32
"	45	55
"	60	83
DCPA	12	94
Azak (Apr. 1)	15	80
" (Apr. 23)	15	98
" (Apr. 15)	15	100
Betasan	15	98
DMPA	15	73

Table 2. Pre-emergence crabgrass control obtained in lawn turf with experimental herbicides, 1964.

Chemical	Rate, lb/A	Crabgrass Control (%)
Tupersan - W.P.	18	0
" Verm.	6	60
"	12	92
"	18	97
V-21944	9	77
Am. Cy. 9180	15	10
TOK - Em.	12	10
E1-110 - Em.	4	3
" Dry	2	3
"	4	63
"	6	97
UC-22463	10	13

On bentgrass turf, DCPA, Azak, the heavy rate of DMPA, and El-110 showed some injury in August. In mid-September, bandane (45 and 90 lb/A) and Azak (15 and 30 lb/A) showed moderately severe color reduction. These treatments plus DMPA, DCPA at the high rate, El-110, and V-21944 showed some traces of thinning.

Conclusions

Among the newer materials, Azak, Betasan, El-110 and Tupersan showed effective crabgrass control. No apparent injury occurred on Kentucky bluegrass.

Most materials showed some discoloration or thinning of bentgrass turf. Azak at 15 and 30 lb/A and bandane at 45 and 50 lb/A gave serious damage.

New Herbicides For Preemergence Control Of Crabgrass In Turf

by J. F. Ahrens[1/]

The preemergence crabgrass killers DCPA and DMPA have proven to be safe and effective for use on established mixed turf in Connecticut. Both herbi- occasionally injure red fescues, and DMPA sometimes injures Merion Kentucky bluegrass grown in pure stands, but repeated annual applications of these herbicides have not seriously injured mixed bluegrass and fescue turf grasses. While DCPA and DMPA are not safe on newly seeded turf, another material, polychlorodicyclopentadiene isomers, is now available to the public for this use.

In the work reported here, new preemergence herbicides were compared with DCPA, DMPA, or polychlorodicyclopentadiene isomers for use on both established and newly seeded turf.

Procedure and Results

Three trials were conducted in Windsor, Connecticut during 1963 and 1964. Trials A and B were on established turf of Kentucky bluegrass and red fescues; Trial A on sandy loam, and Trial B on fine sandy loam. A third trial was on new turf seeded on sandy loam. All the plots were 3 feet wide by 12 to 16 feet long, and replicated 3 to 4 times in randomized blocks. The herbicides were granular formulations (Table 1) applied with a Danielson-Chambers auger-feed machine.

Established turf: The treatments in Trial A were applied on May 3, 1963, before any crabgrass (*Digitaria spp.*) had emerged. A light rain fell 2 days later. During 1963, rainfall was 1.5 inches below normal in May, 0.8 inches above normal in June, normal in July, and 1.8 inches below normal in August. Crabgrass began to emerge in late May, and with subsequent irrigations was growing uniformly and well in untreated plots by August.

In the spring of 1964, crabgrass seed was broadcast over all plots in Trial A. These plots received no herbicides or irrigations during 1964. The 1964 growing season in Connecticut was cool and extremely dry. The rainfall was 2.6 inches below normal in May, 1.3 inches below normal in June, 0.4 inches below normal in July, and 1.0 inch below normal in August. By late summer crabgrass covered about 85% of the untreated areas.

In Trial B, the herbicides were applied on May 15, 1964, before any crabgrass had emerged. The first rain fell 4 days after herbicide application. Supplemental irrigation was started 2 weeks later and used periodically to

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Table 1. Preemergence Herbicides Tested in 1963 and 1964.

Common name - Chemical name - Formulation - Manufacturer.

a) DCPA (dacthal) - dimethyl 2,3,5,6-tetrachloroteraphthalate - 5% G - Diamond Alkali.
b) DMPA (zytron) - O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate 4.4% G - Dow Chemical Co.
c) polychlorodicyclopentadiene isomers (Bandane) - 10% G - Velsicol Chemical Co.
d) trifluralin + diphenatrile - 2,6-dinitro-N,N-di-n-propyl-a,a,a-trifluoro-p-toluidine + diphenylacetonitrile - Propietary mixture containing 0.09 or 0.11% trifluralin, 3.44 or 4.59% diphenatrile, 0.46% heptachlor and 10-5-5 fertilizer - Eli Lily and Co.
e) benefin - N-butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-p-toluidine - 0.46% benefin on 10-5-5 fertilizer with 0.46% heptachlor - Eli Lily and Co.
f) R-4461 (Betasan) - N-(beta-O,O-diisopropyldithiophosphorylethyl benzenesulfonamide) - 7% G - Stauffer Chemical Co.
g) H-9573 (Azak) - 2,6-di-tert-butyl-p-tolyl methylcarbamate - 5% G - Hercules Powder Co.
h) FW-925 (Tok) - 2,4-dichlorophenyl-4-nitrophenyl ether - 2% G - Rohm & Haas Co.
i) H-1318 (Tupersan) - 1-(2-methylcyclohexyl)-3-phenylurea - 4.3% G and 2.34% G + 10-5-5 fertilizer - E. I. duPont de Nemours & Co., Inc.

keep crabgrass alive and growing. Although the irrigation was not sufficient to maintain optimal growth of the turf grasses, stands of crabgrass were excellent in untreated areas (88% coverage).

The treatments applied in 1963 and 1964 and their effects on crabgrass control are given in Table 2. In 1963, crabgrass control with DCPA, R-4461 and H-9573 was excellent, while control with polychlorodicyclopentadiene isomers was good. The trifluralin-diphenatrile mixture controlled crabgrass adequately when used at twice the suggested rate of application. All 1963 treatments, except the normal rate of trifluralin-diphenatrile, also gave better than 80% control of crabgrass in 1964. The turf in Trial A, consisting mainly of red fescues, was thinned slightly in the fall of 1963 by H-9573 at 21 lbs. per acre. In the fall of 1964, however, thinning of the red fescues averaged 10% with H-9573 at 10.5 lbs. per acre and 25% with H-9573 at 21 lbs. per acre.

The 1964 treatments in Trial B included several herbicides not tested in 1963. DCPA, DMPA, H-9573, benefin and H-1318 provided excellent control of crabgrass, while polychlorodicyclopentadiene isomers provided only adequate control, and R-4461, FW-925 and the trifluralin-diphenatrile mixture gave poor control at the rates tested. None of the treatments applied in 1964 injured the bluegrass-red fescue turf.

Table 2. Effects of Preemergence Herbicides on Crabgrass Control in Established Turf in 1963 and 1964.

	Trial A			Trial B	
	Treatments applied 5/3/63			Treatments applied 5/15/64	
Herbicide	Rate a.i lbs/A	% control 8/1/63	% control 9/28/64	Rate a.i lbs/A	% control 9/15/64
DCPA	11.5	92	94	11	87
DMPA	-	-	-	15	97
polychlorodi-cyclopentadiene isomers	32	85	94	35	81
R-4461	15	90	98	15	44
	21	93	99	-	-
	30	92	99	30	76
trifluralin + dephenatrile (+fertilizer)	0.4+20	73	60	0.5+15	82
	0.8+40	92	78	-	-
H-9573	10.5	90	83	10	92
	21	98	93	20	93
benefin (+fertilizer)	-	-	-	2	94
	-	-	-	4	99
H-1318	-	-	-	8	94
	-	-	-	16	97
FW-925	-	-	-	8	9
	-	-	-	16	6

Newly seeded turf: Kentucky bluegrass was seeded at a rate of 2 lbs. per 1000 square feet on April 8, 1964, following the normal liming and fertilizing. Polychlorodicyclopentadiene isomers and H-1318 were applied on May 1 when the bluegrass had reached the 2-leaf stage and was about 1/2 inch high. A few crabgrass seedlings (1-leaf stage) also were present in the plots at this time. The plots were irrigated 4 days after the herbicide treatments and then as needed during the spring and summer. Crabgrass covered about 75% of the area in untreated plots by September.

The results are given in Table 3. Polychlorodicyclopentadiene isomers reduced stands of the bluegrass, but had very little effect on the stand of crabgrass. H-1318, however, effectively controlled crabgrass without

severely affecting stands of bluegrass. Fertilizer added to H-1318 slightly improved crabgrass control and increased the stand of bluegrass.

Table 3. Effects of Herbicides on Newly Seeded Kentucky Bluegrass and Crabgrass.

Herbicide	Rate a.i. lbs/A	% Stand of bluegrass 5/29/64	% Stand of bluegrass 10/20/64	Crabgrass 9/15/64 1/ % Stand	Crabgrass 9/15/64 1/ % control
Check		75	74	72	0
polychloro-dicyclopenta-diene isomers	35	38	54	86	0
	70	38	43	59	19
H-1318	2	51	66	14	81
	4	60	76	5	93
	8	63	80	1	99
H-1318 (+fertilizer)	2	74	83	8	89
	4	70	86	1	99

1/ % control based on stand in treated relative to untreated plots.

Neither polychlorodicyclopentadiene isomers nor H-1318 controlled knotweed (Polygonum aviculare), lambsquarter (Chenopodium album), shepherd's purse, (Capsella bursa pastoris), or carpetwedd (Mollugo verticillata). Pepperweed (Lepidium capestre) was more prevalent in H-1318 plots than in untreated plots in the fall. However, H-1318 controlled stinkgrass (Eragrostis cilienensis) and goosegrass (Eleusine indica). Surviving crabgrass plants in plots treated with H-1318 often were very shallow-rooted.

Summary and Conclusion

Several new preemergence crabgrass killers were compared with normal rates of DCPA and DMPA on established turf, and one new herbicide was compared with polychlorodicyclopentadiene isomers on seedling bluegrass.

Polychlorodicyclopentadiene isomers did not perform as well as previously in established turf when applied in May during the dry 1963 and 1964 seasons. The residual control of crabgrass extending into the second season in these tests and into the third season in other tests with polychlorodicyclopentadiene isomers suggests that polychlorodicyclopentadiene isomers could be more effective when applied earlier in the season. Polychlorodicyclopentadiene isomers was not safe or effective when applied on seedling bluegrass as crabgrass was starting to emerge.

R-4461 was very effective in 1963, but was less so in 1964 when the interval between treatments and rainfall was greater. It has already been established that R-4461 is volatile, and must be sealed in by rainfall or irrigation soon after application.

A proprietary mixture of trifluralin and diphenatrile provided erratic control of crabgrass in these tests.

H-9573 at 10 and 10.5 lbs. per acre controlled crabgrass effectively in 1963 and 1964, with slight to moderate injury to red fescue from the 1963 treatment. Benefin and H-1318 appeared safe and very effective on established turf in 1964. All three compared favorably with DCPA or DMPA in these tests. H-1318 also appears very promising for use on newly seeded bluegrass.

Applied on established turf in May 1964, FW-295 at rates of 8 and 16 lbs. per acre did not control crabgrass adequately.

Control of crabgrass the second season after treatment with H-9573, polychlorodicyclopentadiene isomers and R-4461 suggests that attention be given to reduced rates of application the second year. Effects of repeated annual application of these materials also require evaluation.

Table 1. Identification of generic name or experimental number by formulation.

OCS-21693	=	Velsicol experimental
ASC-22	=	" "
OCS-21694	=	" "
R-4461	=	N-Beta(-O,O-diisopropyl dithiophosphoryl ethyl) benzene sulfonamide; Stauffer Chemical Co. "Betasan" or Mallinckrodt Chemical (emulsion) "Presan".
H-1318	=	1-(2-methylcyclohexyl)-3-phenylurea; DuPont Co. "Tupersan".
bandane	=	polychorodicyclopentadiene isomers, Velsicol Chemical Co.
DMPA	=	O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate; Dow Chemical "Zytron".
DCPA	=	dimethyl 2,3,5,6-tetrachloroteraphthalate; Diamond Alkali Co. "Dacthal".
H-9573	=	2,6-di-tert-butyl-p-tolyl methylcarbamate; Hercules Powder. "Azak".
EH 9180	=	American Cyanamid experimental
EH 52445	=	" " "
EH 51911	=	" " "
FW-925	=	2,4-dichlorophenyl 4-nitrophenyl ether; Rohm & Haas Co. "TOK-E".
benefin	=	N-butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-p-toluidine; Eli Lilly "Binnell".
AIT-207	=	30:1, diphenatrile: trifluralin, Eli Lilly "Greenfield TACK".

Results and Discussion

Maximum seasonal discoloration, turf thinning (Oct.) and estimated percent crabgrass control (Oct.) are shown in Tables 2,3,4,5 for the various tests. Wedgewood data are not listed in tabular form since the turf injury was the only useful result. Cedarbrook data (Table 5) are shown by replication due to the most unusual degree of variability which resulted and will be discussed separately except for turf injury.

The three EH-series materials show no value as turfgrass herbicides in view of poor control and turf injury. H-1318 appears to be very promising on the basis of no visible turf injury to any species and control above 90 percent at rates of 10 lbs. and above. Although comparable results were obtained at lower rates in the University Park tests, it has been generally observed that higher control levels are obtained from seeded crabgrass trials. A shorter period prior to/and of actual germination are usually encountered.

OCS-21693 and 21694 both resulted in excess of 90 percent control at rates above 7 lbs. with slightly better performance from dry formulations up to 20 lbs. No discolor or injury resulted from dry formulations, but the emulsions caused a chlorotic tip at rates between 5 and 9 and more severe chlorosis at 20 lbs. Chlorosis was evident up to six weeks at the highest rate, but only minimal thinning was later evident from the 21693 at 20 lbs. Since their use was confined to bluegrass in one location, further tests should involve other turf species as well.

ASC-22 also resulted in chlorosis type injury on bluegrass from the emulsion and significant thinning from emulsion and dry forms at 40 lbs. Rates in excess of 20 lbs. appear necessary for a higher level of control.

FW-925 treatments caused prolonged burning and appreciable turf thinning on all species in four locations. Crabgrass control was not considered satisfactory.

R-4461 continued to produce no visible turf injury to any mature turf species at rates up to 30 lbs. A slightly lighter green turf may briefly result from the emulsion. Control from 15 and 30 lbs. ranged from 96-99 percent in several locations.

H-9573 injury was confined to red fescue in the Wedgewood test. Fescue was appreciably thinned or still stunted and discolored in October at both the 10 and 20 lb. rates. Injury to other species was not evident in other locations. Control ranged from 89-99 percent from the above rates in three tests.

Bandane crabgrass results were confined to University Park with 91 percent control from 35 lbs. No injury was evident on the bluegrass or bent in the Cedarbrook test.

AIT-207 and the trifluralin derivative, benefin, both resulted in 97-100 percent control at the rates used and did not result in injury to Newport bluegrass or bent.

DMPA and DCPA continued to perform as anticipated at their respective standardized rates, 15 and 11 lbs., and double rates. No injury was evident on the bluegrasses, but bent and red fescue were severely thinned or injured, proportionate to rate. With one exception of DMPA at 92 percent, control ranged from 98-100 percent.

The Cedarbrook test (Table 5) was of considerable interest due to its size and most unusual degree of variability, especially with certain herbicides. The area can only be described as having a good bent population and poorly drained soil under a high level of irrigation to support bent growth.

The dry treatments of DMPA and R-4461 performed normally with excellent control levels. DMPA emulsion varied from 45-95 percent control at both 15 and 30 lb. rates while the R-4461 emulsion gave 0 control at 15 and 50 to 100 at 30 lbs.

H-9573 wp also resulted in 0 control at 10 lbs. and 0 to 95 at 20 lbs. DCPA, the most consistent pre-emergence chemical on the market varied from 0 to 97 percent at the standard 10 lb. rate and 90 to 100 at double rate.

The greatest variability was encountered with H-1318. Regardless of rate and formulation, from 6 to 30 lbs., 27 plots resulted in 0 control and 17 plots ranged from 10 to 96 percent control. It was observed that the youngest appearing crabgrass in this test was limited to H-1318 treated plots.

Despite the variability of the Cedarbrook test, it is believed that the results are worthy of publication and the material, particularly dry formulations, results are related to environmental conditions encountered.

It is concluded that the new experimentals, OCS-21963, OCS-21964, H-1318 and benefin are worthy of extended trials and ASC-22, EH-series and FW-925 show less promise. DCPA, DMPA, AIT-207, bandane, H-9573 and R-4461, the commercially available materials, generally performed as anticipated for crabgrass control and turf tolerance. R-4461 appears outstanding on species tolerance for bluegrass, fescue, bent and *Poa annua*.

Table 2. Percent seasonal crabgrass control, maximum discoloration and turf thinning from a May 14 application of pre-emergence chemicals on Kentucky bluegrass. University Park, Pa., 1964.

		Spray			Dry		
Material	ai/ Acre	% Control	Max Discolor*	Max % Thinning	% Control	Max Discolor*	Max % Thinning
OCS-21693	5	86	0+	0	92	0	0
	7	92	1	0	98	0	0
	9	93	2	0	98	0	0
	20	99	7	5	100	0	0
ASC-22	7.5	67	0	0	68	0	0
	15	72	0+	0	87	0	0+
	22.5	85	1	0	96	0	5
	40	97	7	15	100	0	25
OCS-21944	5	94	0	0	82	0	0
	7	92	0	0	94	0	0
	9	93	1	0	95	0	0
	20	97	5	0	100	0	0
R-4461	15	97	0	0	97	0	0
	30	98	0+	0	98	0	0
H-1318	6	92	0	0	---	---	---
	8	98	0	0	---	---	---
	10	100	0	0	---	---	---
	20	100	0	0	---	---	---
	30	100	0	0	---	---	---
H-1318 #7W	9	---	---	---	99	0	0
	18	---	---	---	100	0	0
H-1318 #6	9	---	---	---	99	0	0
	18	---	---	---	100	0	0
bandane	35	---	---	---	91	0	0
DMPA	15	99	0	0	100	0	0
DCPA	11	100	0	0	---	---	---
H-9573	10	98	0	0	---	---	---

* Discoloration scale - 0 to 10, 0 = none.

Table 5. Percent seasonal crabgrass control from an April 13 application of pre-emergence chemicals on bentgrass. Fairway 18, Cedarbrook C. C., Blue Bell, Pa. (Results by replicate due to unusual variability. Irrigated at regular frequency through dry season; soil heavy and poorly drained).

		% Crabgrass Control							
		Spray				Dry			
Material	Acre	I	II	III	IV	I	II	III	IV
EH 9180	15	0	0	0	0	0	0	0	0
"	25	0	0	0	0	0	0	0	0
EH 52445	3	0*	0*	0*	-0*	0*	0*	-0*	0*
"	6	0*	-0*	0*	-0*	0*	0*	-0*	0*
R 4461	15	0	0	0	0	97	97	96	95
"	30	75	50	80	100	100	100	100	100
FW 925	8	0	0	0	0	--	--	--	--
"	16	0	10	0	0	--	--	--	--
DMPA	15	90*	90*	90*	45*	100*	100*	95*	100*
"	30	85*	95*	55*	45*	100*	100*	100*	100*
H-1318 wp	6	0	0	55	0	--	--	--	--
	8	0	0	0	95	--	--	--	--
	10	0	-0	0	0	--	--	--	--
	20	0	40	0	0	--	--	--	--
	30	0	50	0	55	--	--	--	--
H-1318	9	--	--	--	--	65	0	75	0
#7W	18	--	--	--	--	96	0	0	0
H-1318	9	--	--	--	--	80	0	0	0
#6	18	--	--	--	--	80	0	10	10
H-1318	9	--	--	--	--	45	15	0	0
10-5-5	18	--	--	--	--	55	80	75	0
Bandane-7436	35	--	--	--	--	90	85	95	50
Bandane-1877	35	--	--	--	--	90	90	95	65
H-9573	10	0	0	0	0	--	--	--	--
	20	40	50	0	95	--	--	--	--
DCPA	11	90*	97*	0*	0*	--	--	--	--
	22	100*	90*	98*	100*	--	--	--	--
EH 51911	5	0	0	0	0	--	--	--	--
	10	0	0	0	0	--	--	--	--
benefin gran	2	--	--	--	--	50	10	85	10
" "	4	--	--	--	--	90	90	90	50
" "	6	--	--	--	--	95	95	100	90
AIT-207	10/M	--	--	--	--	90	70	80	90
"	20/M	--	--	--	--	95	80	80	90
"	30/M	--	--	--	--	98	97	100	95

* Bent reduction.

HAWKWEED CONTROL WITH TURF HERBICIDES

S. W. Bingham[1]

Hieracium pilosella L. (hawkweed) is a perennial plant which forms a carpet of stolons and leaves. The leaves form a basal rosette and are setose on both surfaces. The stolons are filiform and bristly. Hawkweed develops in dense spots spreading by both seed and stolons. It presents a weed problem primarily in lawns, pastures, other turf areas, and abandoned open land in cool climates.

The purpose of these studies was to evaluate herbicides for control of heavy stands of hawkweed.

Methods and Materials

Experimental areas were selected with heavy stands of hawkweed for these studies. Since the problem occurs mainly in turf, herbicides that are normally used in turf were selected for evaluation (1,2). Dimethylamine salt of 2-methoxy-3,6-dichlorobenzoic acid (dicamba), butoxyethanol ester of 2,4-dichlorophenoxyacetic acid (2,4-D), dimethylamine salt of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), dimethylamine salt of 2-(2,4,5-trichlorophenoxy)propionic acid (silvex), potassium salt of 2-methyl-4-chlorophenoxypropionic acid (MCPP), 4-amino-3,5,6-trichloropicolinic acid (picloram), and 3,5-diiodo-4-hydroxybenzonitrile (ioxynil) were evaluated in these studies. A common surfactant, alkylaryl polyoxyethelene glycol in isopropanol (X-77) was added to each treatment as ¼ percent of spray. Some evaluations with dicamba included 0, ¼, 1, and 4 percent concentrations of X-77 in the spray solution. An untreated check plot was included in each replication. Minimum size 10 ft by 10 ft plots were used in a randomized block design with three replications.

Herbicides were applied with a knapsack sprayer equipped with Spraying Systems' TK 5 nozzle tip. Applications were made in two directions, one pass perpendicular to the other, to apply 60 gpa total spray. The sprayer was equipped with one nozzle and each swath was 40 inches wide.

The data presented were recorded at 6 to 7 weeks after herbicide treatment. Hawkweed control ratings were made by two men and averaged for analysis. Soil samples 12 by 12 by 3 inch depth were washed or crumbled away from plants and roots to obtain weights of hawkweed remaining in plots.

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Results and Discussion

Hawkweed flowers during May to July in Virginia. As for many weeds, the flowering stage was observed to be the time that homeowners requested control measures. Hawkweed control following various herbicide treatments during the flowering stage are presented in Table 1. With two exceptions, herbicides and rates used were generally suggested for control of various broadleaf weeds in lawns and other turf areas. Some control of hawkweed was observed with each of the herbicide treatments, and the amount of control increased with higher rates of herbicides. The herbicides were ranked in the order of decreasing effectiveness for hawkweed control as follows: dicamba, 2,4-D, 2,4,5-T, silvex, and MCPP. Dicamba and 2,4-D treatments reduced hawkweed weights per sq ft area more than 98 percent when compared to untreated plots.

Ioxynil gave initial browning of hawkweed which appeared to be contact action. However, hawkweed regrowth occurred from crowns within a few weeks. Picloram gave immediate browning of hawkweed shoots and prevented early regrowth yielding 95% reduction in hawkweed weights.

Since leaves and stolons of hawkweed were bristly or setose, the effect of various amounts of surfactant in the spray mixture was evaluated using dicamba at 1 and 2 lb/A rates applied in July. At this time flowering of hawkweed ceased and vegetative growth was under way. Stolons were developing and new plants were being pegged down as a rosette of leaves. At this stage existing hawkweed was eliminated 100 percent with 1 lb/A of dicamba regardless of the amount of surfactant in the spray mixture.

At the same time, an experiment was initiated to evaluate dicamba and 2,4-D alone and in mixtures for hawkweed control (Table 2). In general, dicamba appeared superior to 2,4-D at comparable rates of application and completeness of hawkweed control. The mixtures of 2,4-D and dicamba were not substantially better than dicamba alone.

Hawkweed seedlings emerged during July to October and plots with complete control earlier were re-infested to various degrees by November. Seedling hawkweed formed rosettes of leaves but had not produced stolons during the first fall growing season.

A second experiment was initiated in September to evaluate the effects of surfactant on effectiveness of dicamba for hawkweed control (Figure 1). By this time vegetative growth was slow again. New stolons had developed and rosettes were well established or rooted at the crowns. In general, increasing surfactant increased the control obtained with each rate of dicamba used. Dicamba at ¼ lb/A with 4 percent surfactant was equally effective to 1 lb/A with no additional surfactant beyond that in the formulated herbicide.

Table 1. Hawkweed control following various herbicide treatments on June 5, 1964.

Herbicide[1]	Rate lb/A	Control Ratings[2]	July 24, 1964 Weight of hawkweed shoots, stolons and roots g/sq ft[3]
dicamba	½	6	76
	1	9	42
	2	9.7	4
MCPP	½	1	193
	1	1	167
	2	1	135
silvex	½	3	157
	1	4	102
	2	6	86
2,4,5-T	1	5	87
	2	6	32
2,4-D	2	9	4
picloram	¼	9	34
	½	9	11
ioxynil	½	5	87
check	-	0	207

[1] All treatments were applied with ½% X-77 in spray solution
[2] 0 = no control; 10 = complete control of hawkweed as visually estimated, average 2 men.
[3] Soil samples 12" x 12" x 4" depth were washed or crumbled to obtain intact hawkweed for weights.

Summary

Five herbicides normally used in turf were evaluated for hawkweed control. In order of decreasing effectiveness the herbicides were listed as follows: dicamba, 2,4-D, 2,4,5-T, silvex and MCPP.

Hawkweed responded best to dicamba and 2,4-D when applied in July, next in September and least during June. These dates corresponded to vegetative growth with stolon production, maturing rosettes and degenerating stolons, and flowering stages, respectively.

Surfactant increased effectiveness of dicamba treatments for hawkweed control.

Table 2. Hawkweed control following various herbicide treatments on July 25, 1964.

Herbicide[1]	Rate lb/A	Control Ratings[2]	Weight of hawkweed shoots, stolons and roots g/sq ft[3]
dicamba	½	9	3
	1	10	0
	2	10	0
2,4-D	1	8	2
	2	9.7	0.2
dicamba + 2,4-D	¼ + 1	9	1
	½ + 1	9.7	0.2
	1 + 1	9.7	0.2
check	--	0	105
	--	0	85

[1] All treatments were applied with ¼% X-77 in spray solution.
[2] 0 = no control; 10 = complete control of hawkweed as visually estimated, average 2 men.
[3] Soil samples 12" x 12" x 4" depth were washed or crumbled to obtain intact hawkweed for weights.

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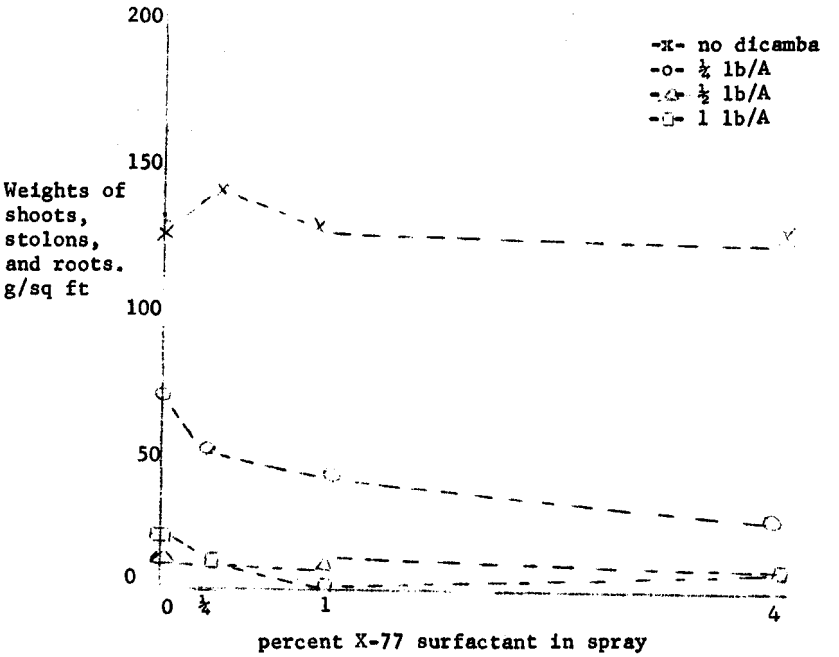

Figure 1. Effect of X-77 surfactant on hawkweed control with various rates of dicamba applied September 17, 1964.

CHEMICAL CONTROL OF KNOTWEED AND CLOVER IN LAWN TURF[1]

J. A. Jagschitz and C. R. Skogley[2]

Knotweed (Polygonum aviculare L.) is one of the most difficult lawn weeds to eradicate. It is most troublesome on areas of thin turf and compacted soils. Although good turf management is needed, a safe and effective herbicide would be useful. Chemical weed killers normally employed in turf management do not consistently control knotweed. Since clover (Trifolium repens) is sometimes present with knotweed, a herbicide that would control both weeds would have great value.

A test was initiated in April 1964 to evaluate standard and new pre- and postemergent type herbicides for the selective control of knotweed and clover in lawn-type turf. Various rates, formulations and combinations of herbicides were used. To determine seasonal effects and the degree of knotweed susceptibility at various stages of growth, applications were made in April, June or July.

Materials and Methods

The experiment was located on lawn turf on the campus of the University of Rhode Island. The turf was predominantly Kentucky bluegrass (Poa pratensis) and annual bluegrass (Poa annua) with traces of creeping red fescue (Festuca rubra L.) and colonial bentgrass (Agrostis tenuis Sibth.). The weed population consisted chiefly of knotweed and white clover.

Irrigation was not used during the test period, although the season was dry. Serious drought conditions did not exist. The area was mowed regularly at a height of about two inches. Mowing was not done at least three days before and after chemical applications.

Forty-nine herbicide treatments and five check plots were completely randomized in each of four blocks. Individual plot size was 4 by 5 feet. Seventeen treatments were applied on April 9, twenty-one on June 9 and eleven on July 21, 1964. The herbicides, formulations, rates and their date of application are shown in Table 1. Chemical name and source of these herbicides are shown in the Appendix.

Spray treatments were applied in water at 109 gallons to the acre using a pressure regulated hand sprayer at 30 psi. All granular formulations were applied by hand to moist turf.

The potential knotweed population for the season was estimated to be 776 seedlings to the square foot. Counts were made using 3x3-inch frames in each of eight check plots at various time intervals. Germination started

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about March 25. When the first herbicide treatments were applied on April 9, about 73% of the potential knotweed was evident. These seedlings were in the first true-leaf stage. By April 23 about 93% were present with 99% by May 7. No new seedlings were evident after May 27. When the second series of herbicides were applied on June 9, knotweed ranged in size from the four-leaf stage to one of several branches. For the final herbicide series on July 21, the knotweed was well matured with some flowering and seed present.

Visual knotweed cover estimates were made on August 25 for all plots. Percent control was based on the reduction when compared to the average cover of the check plots. Clover control for the April treatments was also based on this method. For the June and July treatments clover control was based on estimates made before treatment considering the check plot variation to August 25. Visual turf discoloration estimates were made in April, May, June and August. The scale used was 0-5 with 0 indicating no discoloration and 5 complete brown turf.

Results and Discussion

Data in Table 1 indicate the degree of knotweed control, clover control and turf discoloration from the various herbicides applied in April, June and July.

Azak, Betasan, DCPA (Dacthal), EL-110, Trifluralin and Tupersan, preemergent type herbicides applied in April, were ineffective in controlling knotweed or clover. Since 73% of the potential knotweed population was present at the time of treatment, possibly application before germination would be more effective. Bandane and DMPA (Zytron) produced significantly better knotweed control than other preemergent type herbicides. Bandane controlled 70% of the knotweed when treated in the seedling stage, but only 38% in the branching stage. DMPA was the most effective giving better than 91% control in the seedling and branching stages, but only 74% control of mature knotweed. Bandane and DMPA were ineffective against clover. Turf discoloration from all preemergent type herbicides was negligible.

Endothall applied in April and June gave less than 52% control of clover. Knotweed control in April was only 67%. Although control was fair (82%) from the June application, temporary objectionable turf discoloration was produced. 2,4,5-T produced less than 54% knotweed control from applications made in April and June. Clover control was at least 91% with negligible turf discoloration.

Silvex produced fair control (82%) of knotweed in the seedling stage and significantly less control as knotweed matured. Clover control was good (99-100%) from all three dates of application. Turf discoloration was moderate from the July application and was greater than that of other herbicides applied on this date. The dry application of silvex at the 3-lb rate controlled less knotweed than the spray at half the rate. Clover control was 100% for both the dry and spray treatment.

Table 1. Knotweed control and clover control on August 25 and maximum turf discoloration from April to August in lawn-type turf treated with various herbicides on three dates in 1964.

HERBICIDE	ai AND FORMULATION	lb ai/A	% KNOTWEED CONTROL TREATMENT DATE 4/9	6/9	7/21	% CLOVER CONTROL TREATMENT DATE 4/9	6/9	7/21	MAX TURF DISCOLORATION[1] TREATMENT DATE 4/9	6/9	7/21
Azak	80% WP	15	13	-	-	35	-	-	0	-	-
Bandane	4#/gal	35	70	38	-	25	5	-	0	0	-
Betasan	"	15	10	-	-	37	-	-	0	-	-
DCPA	75% WP	10	16	-	-	0	-	-	0	-	-
DMPA	3#/gal	15	96	92	74	30	0	36	0	.1	.2
DMPA + Dicamba *	3#/gal+4#/gal	15+.5	-	99	-	-	100	-	-	.8	-
Dicamba *	4#/gal	.5	94	97	97	97	100	100	.1	.2	.6
"	"	1	78	100	99	100	100	100	.4	.3	.7
"	1% Verm	1	-	94	97	-	100	100	-	0	.8
Dicamba * + 2,4-D*	4#/gal+4#/gal	.5+1	-	99	100	-	100	100	-	.1	.9
2,4-D *	4#/gal	1	-	56	77	-	67	36	-	0	.3
2,4-D xx	"	1.5	60	98	90	6	93	78	.3	.2	.6
"	2% Verm	3	-	32	-	-	9	-	-	.3	-
2,4,5-T xx	4#/gal	1.5	54	40	-	91	100	-	0	.3	-
2-(MCPP) *	"	1	42	67	-	79	100	-	0	.4	-
"	"	2	63	74	-	95	100	-	.4	.1	-
"	"	3	-	81	95	-	100	99	-	.1	.3
"	2% Verm	3	-	10	-	-	99	-	-	0	-
2-(MCPP)*+2,4-D*	4#/gal+4#/gal	1+1	-	94	93	-	97	99	-	.1	.9
EL-110	2#/gal	2	28	-	-	18	-	-	0	-	-
Endothall	"	1.5	67	82	-	51	47	-	.3	2.3	-
Picolinic acid	"	.125	-	98	-	-	100	-	-	0	-
" "	"	.25	94	99	97	100	100	100	.3	.3	.5
Silvex xx	4#/gal	1.5	82	47	44	99	100	99	0	.3	1.4
"	2% Verm	3	-	21	-	-	100	-	-	.1	-
Trifluralin	4#/gal	1.5	29	-	-	16	-	-	0	-	-
Tupersan	50% WP	9	40	-	-	13	-	-	0	-	-
Checks	-	-	(40% cover)			(21% cover)			0	0	0
LSD 5%			28	27	17	37	13	13			

[1] Turf discoloration; 0 = none, 5 = brown

*dimethylamine

xx butoxy ethanol ester

Picolinic acid at the 1/4-lb rate produced at least 94% control of knotweed at all stages of growth. Clover control was 100% and turf discoloration was slight. The 1/8-lb rate used in June was also effective in control.

The amine formulation of 2,4-D at the 1-lb rate applied in June and July produced poor control of knotweed and clover. A more effective treatment was 2,4-D ester at the 1½-lb rate. Significantly better knotweed control was obtained in June (98%) and July (90%) than in April (60%). The same was true for clover control where the percentages were 6, 93 and 78 for April, June and July respectively. The dry formulation used in June at twice the spray rate of 1½-lb gave significantly less knotweed and clover control. Turf discoloration from 2,4-D treatments was slight, being more evident in July during hot, dry weather.

Rates of 2-(MCPP) up to 2 lb applied in April and June produced less than 75% control of knotweed. The 3-lb rate in June and July produced 81% and 95% control respectively. The addition of 1 lb of 2,4-D to 1 lb of 2-(MCPP) significantly increased knotweed control to 94% in June. This mixture was as effective (93-94%) as 3 lb of 2-(MCPP) applied alone in June and July. The dry formulation of 2-(MCPP) at 3 lb produced significantly less knotweed control (10%) than the spray (81%) while clover control was similar (99-100%). Over 90% clover control was produced by 2-(MCPP) at 2 lb in April, 1 lb in June, 3 lb in July (only rate used) and the mixture of 2-(MCPP) and 2,4-D at 1 lb each in June and July. Turf discoloration was negligible from these treatments although slight discoloration resulted from the mixture applied in July.

Dicamba applied at the 1/2-lb rate in April, June and July produced upwards of 94% control of knotweed and clover. The 1-lb rate also was effective although, for some reason, the application in April gave only 78% control of knotweed. The addition of 15 lb of DMPA in June or 1 lb of 2,4-D in June and July to 1/2 lb of dicamba was not necessary since alone DMPA and dicamba were effective. Dry formulations of dicamba were equally as effective as sprays. Turf discoloration was negligible in April and June and slight in July.

Dandelion and broadleaved plantain counts were made before and after the June and July treatments. Effective control of these weeds was obtained with 2,4-D. Dicamba and picolinic acid gave some control of dandelion while 2,4,5-T, 2-(MCPP), silvex and picolinic acid gave some control of plantain. Adding 2,4-D to dicamba or 2-(MCPP) effectively eradicated both weeds.

Conclusions

Various pre- and postemergent type herbicides were evaluated for the control of knotweed and clover in lawn turf. Applications were made in April, June and July at various stages of knotweed growth. Based on the results of these tests the following conclusions were reached:

1. Knotweed germination started in late March and continued until May.

2. Good control of knotweed in all three stages of growth was produced by dicamba at 1/2 lb and picolinic acid at 1/4 lb to the acre.

3. Zytron at 15 lb to the acre gave good control of knotweed in the two early stages of growth but was less effective against mature knotweed.

4. Good knotweed control was obtained on some of the application dates with 2-(MCPP) at 3 lb, 2,4-D at 1½ lb, 2-(MCPP) + 2,4-D at 1 lb each, dicamba + 2,4-D at 1/2 + 1 lb, and picolinic acid at 1/8 lb to the acre.

5. Consistently good clover control was obtained with dicamba at 1/2 lb, 2-(MCPP) at 2 lb, silvex at 1½ lb, 2,4,5-T at 1½ lb and picolinic acid at 1/4 lb.

6. Adding 2,4-D to dicamba or 2-(MCPP) resulted in good control of dandelion and plantain.

7. Dry formulations of 2,4-D, 2-(MCPP) and silvex were less effective against knotweed than sprays while both formulations of dicamba produced good results.

8. Endothall produced the only objectionable turf discoloration in this test. Silvex, dicamba + 2,4-D and 2-(MCPP) + 2,4-D produced some discoloration when applied in July. Turf discoloration was more evident from herbicides applied in July than when applied earlier in the season.

Appendix

The chemical name and source of the herbicides used in this test are as follows:

Azak = 2,6-di-*tert*-butyl-*p*-tolyl-methylcarbamate (Hercules); Bandane = Polychlorodicyclopentadiene isomers (Velsicol); Betasan = N-(beta-*O*,*O*-diisopropyl-dithiophosphorylethyl)-benzene sulfonamide (Stauffer); DCPA (Dacthal) = dimethyl 2,3,5,6-tetrachloroterephthalate (Diamond Alkali); DMPA (Zytron) = O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate (Dow); Dicamba (Banvel D) = 2-methoxy-3,6-dichlorobenzoic acid (Velsicol); 2,4-D = 2,4-dichlorophenoxyacetic acid (Amchem); 2,4,5-T = 2,4,5-trichlorophenoxyacetic acid (Amchem); 2-(MCPP) = 2-(2-methyl-4-chlorophenoxy) propionic acid (Chipman); EL-110 = an analog of trifluralin (Eli Lilly); Endothall = 7-oxabicyclo-(2.2.1) heptane-2,3-dicarboxylic acid (Pennsalt); Picolinic acid (Tordon) = the K salt of 4-amino-3,5,6 trichloropicolinic acid (Dow); Silvex = 2-(2,4,5-trichlorophenoxyl) propionic acid (Amchem); Trifluralin (Treflan) = a,a,a-trifluoro-2,6-dinitro-*N*,*N* dipropyl-*p*-toluidine (Eli Lilly); and Tupersan = 1-(2-methylcyclohexyl)-3-phenylurea (DuPont).

CLOVER AND KNOTWEED CONTROL

B. R. Fleming, J. M. Duich and G. J. Shoop[1]

The introduction of dicamba and MCPP as turfgrass herbicides has intensified a renewed interest in control of harder to kill weeds, particularly in bentgrass. While these compounds are being noted for clover, knotweed and chickweed control, it is becoming apparent that they lack activity on certain broadleafed weeds easily controlled by 2,4-D. This paper covers several trials on the above herbicides used alone and in combination.

Materials and Methods

Two separate tests were conducted at the Merion Golf Club, West Course, Ardmore, Pa. Fairway No. 1 was selected for its heavy population of knotweed. The fairway is not irrigated and turf consisted predominantly of Poa annua and scattered bent and bluegrass.

Fairway 11 had a heavy white clover population and dandelion, buckhorn plantain and grass-leaved stitchwort. Knotweed was also present, but not visually evident at time of spraying. Turf population was similar to Fairway 1. Both test areas were treated with the same chemicals on April 15, 1964.

Treatments were triple-replicated, 6 x 20' plots, sprayed with a fan nozzle boom sprayer at 45 gpa and 35 psi. Knotweed appeared fully germinated, approximately two-inches high, and had formed true leaves. The other weeds were also in active growth, but the turf was just recovering from winter dormancy. The area was not subjected to rainfall until April 19, four days after treatment. Over three inches of rain were received by April 31 followed by a five month drought.

Materials, rates and weed control results are shown in Table 1. Final ratings were made in early October.

Results and Discussion

Dicamba proved to be very effective on clover, with the low rate of 0.125 lb. resulting in 96 percent control, and higher rates up to 1.0 lb. giving complete control. Knotweed and stitchwort were very effectively controlled at rates of 0.5 to 1.0 lb. Knotweed control by dicamba was appreciably higher than other materials on Fairway 11 where it was covered by clover and it is assumed that root absorption may be a factor. Dicamba exhibited slow activity on dandelion and buckhorn with poor to good control and poor to fair control, respectively, with rates up to 1 lb.

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Table 1. Control of clover, knotweed and other broadleaf weeds treated on April 15 with certain chemicals. Final seasonal rating, October, 1964. Merion Golf Club, Ardmore, Pa.

Material	Acre Rate	No. 11 Fairway % Control Clover	Knot-weed	Dande-lion	Buck-horn	Stitch-wort	No. 1 Fairway % Control Knot-weed
Dicamba*	0.125	96	35	Poor	Poor	Fair	77
"	0.25	99	89	Poor	Poor	Good	80
"	0.50	100	95	Good	Poor	Exc	98
"	0.75	100	98	Good	Poor	Exc	99
"	1.00	100	97	Good	Fair	Exc	100
MCPP*	1.00	83	0	Poor	Poor	Fair	40
"	1.50	97	7	Fair	Fair	Fair	53
2,4-D+ 2,4,5-T (1:1)	1.00	40	0	Exc	Exc	Poor	60
2,4-DP	1.00	98	0	Poor	Good	Fair	10
2,4,5-TP	1.00	100	0	Poor	Poor	Fair	10
MCPA	1.00	0	20	Fair	Poor	Good	35
2,4-D+ 2,4,5-TP (2:1)	1.00	97	10	Exc	Good	Good	50
"	1.50	98	40	Exc	Exc	Exc	90
2,4-D+MCPP (2:1)	1.00	27	60	Exc	Good	Fair	63
"	1.50	57	66	Exc	Exc	Fair	88
2,4-D+ Dicamba (4:1)	0.84	97	94	Exc	Good	Fair	95
"	1.25	99	94	Exc	Exc	Good	99

* Dicamba and MCPP slow-acting on dandelion and buckhorn.

Note: Fairway 11 was predominant with clover when sprayed on April 15.
Fairway 1 was predominant with knotweed when sprayed on April 15.

Control on these weeds was increased by the 2,4-D + dicamba (4:1) combination at 0.84 and 1.25 lbs., but stitchwort control fell off.

MCPP resulted in 83 and 97 percent control of clover at 1.0 and 1.5 lbs., respectively, 40 and 53 percent control of exposed knotweed and 0 to 7 in the clover, knotweed combination area. Dandelion and buckhorn activity by MCPP was similar to dicamba. The 2,4-D + MCPP (2:1) combination at 1.0 and 1.5 lbs. showed an increased activity on both knotweed areas, 60 to 88 percent control, dandelion and buckhorn, but fell off on clover to 27 and 57 percent control.

2,4,5-TP (silvex) at 1.0 lb. was very similar in its activity on all weeds to MCPP at 1.5. However, the 2,4-D + 2,4,5TP (2:1) combination at 1.5 lbs. resulted in an excellent level of control on all weeds except the clover-knotweed combination. In the latter, it is believed the material could not reach the knotweed leaves due to the clover canopy.

2,4-DP at 1.0 lb. resulted in 98 percent clover control, poor knotweed control and was good and fair on buckhorn and stitchwort, respectively. MCPA proved to be generally inadequate on almost all the weeds.

The synergistic effect of 2,4-D with the newer herbicides appears promising, but all combinations will require exhaustive tests for species tolerance as well as broad-spectrum weed control. In early May it was observed that Poa annua and bent were affected by some of the treatments. However, the following drought and fading out of the Poa in June obscured this portion of the study.

Putting Green Test

The No. 18 green at the Cedarbrook C. C. was treated with dicamba at 0.5 and 0.75 lbs. ai/A and MCPP at 1.0 and 1.5 lbs. on May 11, 1964. Turf consisted of two-year old C-1 + C-19 vegetative bent and a widespread young white clover population. The herbicides were applied to 6 x 20' plots with a 3' surrounding border at 45 gpa and 35 psi with a boom sprayer. Inadvertently, a plot was sprayed with 0.75 lbs. of dicamba and 1.0 MCPP as noted in the injury rating in Table 2. All treated plots were rated as resulting in complete control for the season.

Table 2. Injury rating of dicamba and MCPP treated green 9 days after May 11 application. Cedarbrook C. C., Blue Bell, Pa.

Material	ai/A	replications	ave injury*
dicamba	0.50	8	1.0
dicamba	0.75	3	1.7
MCPP	1.00	7	0.4
MCPP	1.50	4	1.0
dicamba + MCPP	0.75 + 1.0	1	3.0

* Scale 0 to 10, 0 = none

Superintendent L. W. Scott did not consider the injury to be more serious than a temporary discoloration and was most pleased with the clover control results.

Conclusions

1. Dicamba was very effective for clover at rates as low as 0.125 lbs. ai/A, and seedling knotweed and grass-leafed stitchwort at 0.5 lbs. Relatively poor activity on broadleafed weeds was increased by a 2,4-D + dicamba combination.

2. MCPP required 1.50 lbs. for excellent clover control and gave generally fair control on knotweed, stitchwort, dandelion and buckhorn. 2,4-D + MCPP combination increased activity over MCPP alone on all weeds except clover, which resulted in a reduction.

3. Activity of 2,4,5-TP was broadened with the addition of 2,4-D, but the 2,4-D + dicamba combination was equally effective at a lower rate.

4. 2,4-DP activity at 1.0 lb. was limited to clover and buckhorn. MCPA was generally ineffective on weeds involved.

5. Dicamba and MCPP were shown to be used safely on a C-1 + C-19 putting green with excellent clover control and unobjectionable injury resulting.

CLOVER, CHICKWEED AND DANDELION CONTROL WITH HERBICIDES IN LAWN AND GOLF COURSE TURF[1]

C. R. Skogley and J. A. Jagschitz[2]

Three of the most common turf weeds are mouseear chickweed (Cerastium vulgatum L.), clover (Trifolium repens) and dandelion (Taraxicum officinale Weber.). Dandelion is usually controlled with 2,4-D whereas the other two are more difficult to eliminate and require herbicides of a more specific nature. Herbicides used regularly for the specific control of chickweed and clover seldom control dandelion. For this reason chemical combinations are frequently employed for all-inclusive turf weed control. In very recent years new herbicides have been developed that show promise for chickweed and clover control with an improved safety margin for use on turfgrasses. The studies reported in this paper were conducted in an attempt to more fully evaluate some of these newer materials both individually and in combination that might result in safer broad-spectrum weed eradication. These studies are partially based on experience gained in similar research as reported a year ago[3].

Materials and Methods

Three separate tests were executed, two at the Pt. Judith Country Club, Narragansett, R.I. on fairway turf and the third on lawn-type turf at the Experiment Station turfgrass research area. The fairway turf, mowed regularly at 5/8 inch, was an old mixed stand of Kentucky and annual bluegrass, creeping and velvet bentgrass and creeping red fescue. The Experiment Station test was located on an old stand of turf consisting of a mixture of Kentucky bluegrass, creeping red fescue and Colonial bentgrass. The cutting height was 1½ inches. The fairway turf was unwatered whereas the test at the Experiment Station received water as needed to maintain good growth.

Test Number 1 was established at the Pt. Judith Country Club on September 27, 1963. The experimental design consisted of three complete randomized blocks with a plot size of four by eight feet. Soil moisture was high at the time of treatment and grasses and weeds were making good growth. An 8-6-4 grade fertilizer was applied in October at the rate of 15 pounds per 1000 square feet.

Except as noted in Table 1, all materials were applied in 54 gallons of water per acre. A two-gallon pump-type sprayer operated at 30 pounds pressure was used to apply the liquids. All herbicide formulations in test number 1 contained 4 lb ai per gallon except for the following: picolinic acid and endothall had 2 lb, endothall plus silvex had 1.5 lb ai each per gallon and the 2-(MCPP) + 2,4-D + 2,4,5-T combination contained .832 lb, .832 lb and .312 lb per gallon active ingredient respectively.

The plots were observed frequently following treatment to determine whether turf injury would result. Estimates of plot coverage with mouseear chickweed, clover and dandelion were made on September 9, 1964.

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[2]Associate Professor and Research Assistant, respectively, Department of Agronomy and Mechanized Agriculture.

[3]J. A. Jagschitz and C. R. Skogley. Clover and chickweed control in lawn and

Test number 2, located on fairway turf similar to that in test 1, included both liquid and dry formulations. The experimental design was similar to that of test 1 and plot size was four by six feet. Dry herbicide materials were spread by hand, except for spreader application of O. M. Scott products at specified settings, and liquids were applied as in test 1 in 54 gallons of water per acre. Grasses and weeds were growing well when the herbicides were applied on May 28 and 29, 1964.

The plots were observed frequently during the season to watch for turf injury or response and weed control estimates were made in July and again in September.

Chemicals were applied on July 7, 1964 in test number 3. The experimental design consisted of two complete randomized blocks. The plot size was 5 by 26 feet and all chemicals were applied as in tests 1 and 2 in 54 gallons of water per acre. A 10-6-4 grade fertilizer was applied at a rate of 10 pounds per 1000 square feet on July 28. An estimate of plot coverage of clover, mouseear chickweed and dandelion was made at the time of treatment and again at the conclusion of the study on August 20. Control was based on the reduction in weed cover considering check plot variation.

Results and Discussion

Table 1 lists the herbicides included in test 1 and the rates at which they were applied. It also lists the estimates of weed control as recorded on September 9, 1964, nearly one year after treatment.

Initial turf injury was very slight or non-existent for all chemicals with the exception of endothall or endothall-silvex combinations. Four days after chemical application the plots receiving these materials were rated between 1.0 and 2.0 for injury. The rating system used was 0 for no injury and 5.0 as complete kill. By the following spring, injury was not apparent on any plot.

Clover control was near 90 percent or better with all herbicides in the trial with these exceptions: all rates of 2,4-D, 2,4,5-T at 3/4 lb, 2-(MCPP) at 1 lb, endothall and endothall plus silvex. The control of chickweed exceeded 90 percent only with these materials: dicamba at ½ and 1 lb, both dicamba and 2,4-D combinations, all 2-(MCPP) + 2,4-D combinations and the 2-(MCPP) + 2,4-D + 2,4,5-T combination at the heavier rate. Full year dandelion control was not obtained with any of the chemical treatments.

Control of both clover and chickweed in excess of 90 percent was obtained with dicamba at ½ and 1 lb, both rates of dicamba and 2,4-D in combination, 2-(MCPP) at 2 and 3 lb, both 2-(MCPP) and 2,4-D combinations and the 2-(MCPP) + 2,4-D + 2,4,5-T at the heavier rate. The ¼ lb rate of dicamba gave 98 percent control of clover and 88 percent control of chickweed.

For the control of clover or mouseear chickweed, there was little advantage in exceeding ½ lb of dicamba or 2 lb of 2-(MCPP). Also, for clover or chickweed control the benefit of adding 2,4-D to dicamba or 2-(MCPP) was not great. At the ¼ lb rate of dicamba the addition of 2,4-D at 1 lb per acre increased chickweed control from 88 to 96 percent. The additions of 2,4-D to 2-(MCPP) at the 1 lb rate increased clover control from 74 to 90 percent but had little effect on chickweed control. Increasing the rate of dicamba or 2-(MCPP) slightly would seem to result in better control of clover and chick-

Test number 2, established on fairway turf in the spring of 1964, included 90 chemical and 8 check treatments. The herbicides and formulations, rates of application and estimates of clover, chickweed and dandelion control are presented in Table 2.

Since a large number of herbicides and combinations were included, and the difference in control percentage required for statistical significance is large, it is necessary to refer to Table 2 in order to exactly determine herbicide, formulation and rate differences.

Estimates of dandelion control were made on July 15 and again in mid-September when final chickweed and clover control readings were made. It is felt that the July reading for dandelion control reflects the actual control obtained. The substantial general decrease in control between July and September appeared to be the result of the establishment of a new crop of dandelions in late summer, however, the picolinic acid, 2,4-D and 2,4-D + 2-(MCPP) treatments showed nearly as much control in September as in July.

Many treatments gave 99 or 100 percent control of dandelions as rated in July. Only 19 of the 90 chemical treatments gave significantly poorer than 99 percent control. Of the 19, 14 were dry formulations as seen in Table 2.

Dry formulations, again, were generally far less effective in controlling clover and chickweed than were the liquids. Certain formulations of all herbicides gave excellent control of both weeds. The ester formulations of 2,4-D were more effective than were the amines. The triethylamine and butoxy ethanol ester of 2,4,5-T both gave good control. Both liquid and dry ester formulations of silvex gave excellent control of clover and chickweed as did the liquid amines at all rates included.

2-(MCPP) at all rates and formulations and dicamba in the various formulations included gave good and statistically comparable results. Picolinic acid at the three rates included gave excellent control of all three weeds. As seen in Table 2, many of the herbicide combinations resulted in excellent control.

In this study dicamba, silvex and 2,4-D were applied in water volumes of both 54 and 500 gallons per acre. As in test 1, dilution had no significant effect on weed control.

There has been speculation, backed up with some research results (see [3] on first page) that fall application of broadleaved weed killers may result in better control than when the same chemicals were applied in the spring. Since test number 1 (fall applied) and test 2 (spring applied) of this report contained many similar herbicides, another chance for season comparison was provided. In contrast to the earlier studies spring application of many herbicides in this test series produced better control than fall application. The climatic conditions of the particular growing season following application would seem to influence results as greatly as season of application alone.

Turfgrass injury resulting from chemical application was very light. Observations on June 10 indicated slight discoloration with a few treatments. Since the injury was slight and temporary, they are not reported.

Nine chemical and one check treatment were included in test number 3. [illegible] and formulations included and the estimates of average

Table 3. The only turf injury observed during the course of the trial was a slight discoloration on the silvex treated plots. This was obvious on August 7 but not when final readings were taken on August 20.

In this study only 2,4-D failed to give good control of clover. 2,4-D alone gave 30 percent control and all other treatments gave control in excess of 88 percent. 2,4-D, 2,4,5-T and the combination of the two failed to give good control of chickweed. All other treatments had control in excess of 85 percent. Dandelions were controlled in excess of 80 percent only with 2,4-D and combinations of 2,4-D and 2,4,5-T, 2-(MCPP), dicamba or silvex.

All three weeds being observed were controlled effectively with 2-(MCPP) + 2,4-D, dicamba + 2,4-D and silvex + 2,4-D.

Conclusions

Various broadleaved-type herbicides were evaluated for the control of clover, mouseear chickweed and dandelion in fairway and lawn turf. Applications were made in September, May and July in three separate trials. Based on the results of these tests the following conclusions were reached:

1. Under certain conditions all of the weeds included can be safely eradicated with 2,4-D, 2,4,5-T, silvex, 2-(MCPP), dicamba and picolinic acid. Certain combinations of these chemicals may result in improved, overall control.
2. Both dicamba and 2-(MCPP) give a broader-spectrum control when combined with 2,4-D than when used alone.
3. Liquid formulations of the various chemicals give better control than the same chemical in dry formulation when used at comparable rates.
4. Growing conditions following herbicide application influence control results as markedly as does season of application.
5. Dicamba, 2-(MCPP) and picolinic acid gave the most consistent control of clover and mouseear chickweed with the greatest safety in all three tests.
6. Reinfestation of turfgrass areas with dandelion can occur shortly after effective eradication by herbicides.
7. Weed control with dicamba, 2,4-D and silvex was not significantly affected by increasing the spray volume from 54 to 500 gallons of water to the acre.

Appendix

The chemical name and source of the herbicides used in these tests are as follows:

2,4-D = 2,4-dichlorophenoxyacetic acid (Amchem, Diamond Alkali and Dow); 2,4,5-T = 2,4,5-trichlorophenoxyacetic acid (Amchem, Diamond Alkali); 2-(MCPP) = 2,(2-methyl-4-chlorophenoxy) propionic acid (Amchem, Chipman, Morton, Scott); Dicamba = 2-methoxy-3,6-dichlorobenzoic acid (Amchem, Scott, Velsicol); Endothall = 7-oxabicyclo-(2.2.1) heptane-2,3-dicarboxylic acid (Pennsalt); MCPA = 2-methyl-4-chlorophenoxyacetic acid (Amchem); Picolinic acid = 4-amino-3,5,6 trichloropicolinic acid (Dow); and Silvex = 2-(2,4,5-trichlorophenoxy) propionic acid (Amchem, Diamond Alkali, Scott).

Table 1. Control of clover, mouseear chickweed and dandelion in fairway turf treated with various chemicals on September 27, 1963.

Chemical	lb ai/A	Percent control 9/9/64 Clover	Chickweed	Dandelion
2,4-D ***	1.0	15	43	74
2,4-D xx	.75	19	17	46
"	1.0	26	22	35
"	1.5	44	24	62
2,4,5-T xx	.75	68	2	38
"	1.5	97	0	68
2,4,5-T + 2,4-D xx	.75+1.0	93	48	38
2,4,5-T + 2,4-D **	.75+.75	95	17	55
Silvex xx	.75	90	55	29
" (500 GPA)	.75	90	74	38
"	1.5	98	85	25
Silvex **	.75	99	31	33
Silvex + 2,4-D xx	.75+1.0	88	81	30
Dicamba *	.25	99	88	24
" (200 GPA)	.25	98	87	5
" (500 GPA)	.25	99	88	22
"	.5	99	97	24
"	1.0	100	96	66
Dicamba * + 2,4-D ***	.25+1.0	99	98	52
" + "	.5 +1.0	99	97	28
2-(MCPP) *	1.0	74	97	25
"	2.0	99	96	49
"	3.0	98	99	0
2-(MCPP) * + 2,4-D ***	1.0+1.0	90	91	2
" + "	2.0+1.0	98	92	46
2-(MCPP) + 2,4-D + 2,4,5-T	1.1+1.1+.4	91	55	21
" + " + "	1.7+1.7+.6	95	97	11
Picolinic acid k	.125	97	45	53
" "	.25	99	67	27
Endothall	1.5	0	0	2
Endothall + Silvex	1.0+1.0	42	0	11
Check	-	0	0	0
LSD 5%		23	20	NSD
LSD 1%		31	26	
Average weed cover in checks		21%	14%	21 plants

xx 2-ethyl hexyl ester
k Potassium salt
***Alkanolamine salt
**Dacamine

Table 2. Control of clover, mouseear chickweed and dandelion in fairway turf treated with various chemicals in late May 1964.

CHEMICAL AND FORMULATION	ai	# ai/A	AVERAGE PERCENT CONTROL CLOVER 9/17	CHICKWEED 9/17	DANDELION 7/15	DANDELION 9/17
2,4-D ***	4#/gal	1.0	42	56	88	65
2,4-D xx	"	1.0	93	92	99	64
"	"	1.5	100	98	99	59
2,4-D x	"	1.0	100	100	96	74
"	"	2.0	100	100	86	36
"	2% Verm	2.0	44	0	29	37
2,4-D *	4#/gal	1.0	87	74	96	50
"	"	2.0	52	89	100	81
"	2% Verm	2.0	74	24	94	49
"	5% Cob	2.0	33	47	79	38
"	5% Clay	2.0	29	41	70	15
"	5% Verm	2.0	64	45	88	20
"	"	4.0	61	52	95	31
2,4-D **	4#/gal	1.0	94	77	100	83
"	"	2.0	94	82	96	55
"	5% Cob	2.0	4	45	88	43
"	5% Clay	2.0	24	41	80	53
"	5% Verm	2.0	49	27	77	35
"	"	4.0	77	62	97	58
2,4,5-T xx	4#/gal	.75	96	22	75	53
"	"	1.5	100	50	95	75
2,4,5-T x	"	1.5	100	86	54	13
2,4,5-T ****	"	1.5	99	100	89	59
2,4,5-T + 2,4-D xx	4#/gal each	.75+1.0	99	100	99	60
2,4,5-T + 2,4-D **	2#+2#/gal	.5 + .5	99	42	99	57
" + "	"	.75+.75	98	77	99	67
" + "	"	1.0+1.0	91	88	97	23
" + "	2.5+2.5 Cob	1.0+1.0	49	9	64	33
" + "	2.5+2.5 Clay	1.0+1.0	52	42	51	31
" + "	2.5+2.5 Verm	1.0+1.0	92	66	60	12
" + "	2.5+2.5 Verm	2.0+2.0	94	59	90	61
Silvex xx	4#/gal	.75	100	98	98	63
"	"	1.5	100	100	99	35
Silvex x	"	.5	100	98	84	54
"	"	1.0	98	100	97	59
"	"	2.0	100	100	95	36
"	2% Verm	2.0	98	96	70	34
Silvex *	"	2.0	93	89	36	49
Silvex **	4#/gal	1.0	99	98	73	16
"	"	2.0	100	100	94	35
"	5% Cob	2.0	92	56	58	27
"	5% Clay	2.0	73	41	56	22
"	5% Verm	2.0	64	42	69	45
"	"	4.0	87	77	90	38
Silvex (Kapsol)		1.5	100	91	81	34

Table 2 (Cont'd.):

CHEMICAL AND FORMULATION	ai	# ai/A	AVERAGE PERCENT CONTROL CLOVER 9/17	CHICKWEED 9/17	DANDELION 7/15	DANDELION 9/17
Silvex + 2,4-D x	.25+.5#/gal	.5+1.0	100	98	100	64
Silvex + 2,4-D xx	4#/gal each	.75+1.0	98	100	100	47
2-(MCPP) *	"	.5	100	88	63	34
"	"	1.0	100	98	77	41
"	"	2.0	100	100	72	22
"	"	3.0	100	100	92	36
"	2% Verm	2.0	99	70	32	24
"	"	3.0	98	97	71	41
2-(MCPP) x	"	2.0	100	89	52	22
"	"	3.0	100	98	78	62
2-(MCPP) k	6#/gal	1.0	100	100	67	31
"	"	2.0	100	100	84	40
2-(MCPP) k	2.5#/gal	1.0	95	100	68	36
2-(MCPP) (F-1627)	--	2.0	100	97	25	17
2-(MCPP) + 2,4-D *	4#/gal each	.5+1.0	96	100	98	56
" + "	"	1.0+1.0	99	98	99	85
" + "	"	2.0+1.0	100	100	99	83
2-(MCPP) + 2,4-D x	.25+.5#/gal	.5+1.0	90	100	99	83
2-(MCPP)*+ 2,4-D ***	4#/gal each	1.0+1.0	100	100	99	57
2-(MCPP) + 2,4-D	2½#/gal	1.9	100	100	99	56
2-(MCPP) + 2,4-D + 2,4,5-T	.8+.8+.3/gal	1.1+1.1+.4	99	91	99	55
2-(MCPP) + MCPA *	4#/gal each	1.0+1.0	100	100	95	55
MCPA *	4#/gal	1.0	84	95	85	63
Dicamba *	"	.25	98	87	92	33
"	"	.5	100	73	99	62
"	"	1.0	100	100	97	53
"	"	2.0	100	100	99	34
"	1% Verm	.5	100	73	33	23
"	"	1.0	98	88	79	22
"	"	2.0	100	100	99	67
Dicamba * (64-170)	"	1.0	96	90	86	49
Dicamba (VWF-1570)	--	1.0	98	100	92	60
Dicamba (VWF-1411)	--	.5	100	100	84	32
Dicamba + 2,4-D *	4#/gal each	.25+1.0	100	100	99	85
" + "	"	.5+1.0	100	100	99	63
" + "	"	1.0+1.0	100	100	98	59
Dicamba * + 2,4-D ***	"	.5+1.0	100	100	99	57
Dicamba * + 2,4-D x	.125+.5#/gal	.25+1.0	100	97	99	71
Dicamba + MCPA *	4#/gal each	.5+1.0	100	100	96	65
Picolinic acid k	2#/gal	.0625	100	100	99	83
" "	"	.1250	100	83	99	89
" "	"	.25	100	100	99	95

Table 2 (Cont'd.):

CHEMICAL AND FORMULATION	ai	# ai/A	AVERAGE PERCENT CONTROL CLOVER 9/17	CHICKWEED 9/17	DANDELION 7/15	DANDELION 9/17
Dicamba * (500 GPA)	4#/gal	.25	100	97	88	16
Silvex xx (500 GPA)	"	.75	96	97	97	65
2,4-D * (500 GPA)	"	1.0	62	47	99	79
Check	--	--	0	0	0	0
LSD 5%			33	35	28	47
LSD 1%			43	45	37	62
Average weed cover in checks			6%	4%	9%	26%.

*Dimethylamine
**Dacamine
***Alkanolamine
****Triethylamine

xButoxy ethanol ester
xx2-ethyl hexyl ester
kPotassium salt

Table 3. Clover, chickweed and dandelion control following application of several herbicides to lawn-type turf on July 7, 1964.

CHEMICAL	# ai/A	AVERAGE PERCENT CONTROL 8/20/64 Clover	Chickweed	Dandelion
2,4-D *	1.0	30	0	90
2,4,5-T *	1.0	93	6	0
2,4,5-T * + 2,4-D *	1.0+1.0	89	0	93
2-(MCPP) *	1.5	97	100	61
2-(MCPP) * + 2,4-D *	1.5+1.0	99	100	81
Dicamba *	.5	99	86	73
Dicamba * + 2,4-D *	.5+1.0	100	100	98
Silvex x	1.0	100	100	17
Silvex x + 2,4-D *	1.0+1.0	100	96	82
Check	--	0	0	0
LSD 5%		10	8	34
LSD 1%		15	11	49
Average weed cover in checks		30%	10 plants	300 plants

*dimethylamine - 4 lb/gal

xbutoxy ethanol ester - 4 lb/gal

WILD GARLIC CONTROL IN BERMUDAGRASS TURF[1]

S. W. Bingham[2]

Allium vineale L. (wild garlic) and *Allium canadense* L. (wild onion) are serious perennial weeds found in many lawn and highway turf areas over the entire state of Virginia. Wild garlic presents a special problem by producing both hard and soft coated bulbs (5). Some of the hard coated bulbs remain dormant as much as three years in the soil (4).

Wild garlic was found susceptible to 2,4-D applied post-emergence to the garlic (2,3,4). Since some of the wild garlic bulbs remained dormant for extended periods, repeated treatments were required for successful control. Maleic hydrazide at 4 lb/A and 2,4,6-TBA at 2 lb/A repeated twice each year for two to three years gave about 98 percent control of wild garlic bulbs.

The objectives of this study were to evaluate (1) a new herbicide, dimethylamine salt of 2-methoxy-3,6-dichlorobenzoic acid (dicamba) and (2) substituted oleyl amine formulations of phenoxy herbicides for effectiveness in control of wild garlic.

Methods and Materials

An established *Cynodon dactylon* L. (Bermudagrass) turf area in Richmond, Virginia, was selected for this study. Wild garlic shoots numbered about 40 per square foot and were in clumps ranging from 7 to 26 shoots per clump.

Dicamba, oleyl 1,3-propylene diamine salt of 2,4-dichlorophenoxyacetic acid (2,4-D, OPDS), diethanolamine salt of maleic hydrazide (MH), oleyl 1,3-propylene diamine salt of 2-(2,4,5-trichlorophenoxy)propionic acid (silvex, OPDS), and dimethylamine salt of 2-(2,4,5-trichlorophenoxy)propionic acid (silvex) were evaluated as repeated treatments applied on March 26, 1963, November 20, 1963, and March 26, 1964.

A randomized block design with 4 replications of 15 by 40 foot plots were used. The treatments were applied with a knapsack sprayer equipped with Spraying Systems TK 5 flooding tip. Applications were made in two directions,

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one pass perpendicular to the other, to apply 60 gpa total spray. Each trip across the plot covered approximately a 40-inch swath with about two inches spray overlap.

The turf was clipped at approximately weekly intervals during the growing season to a 1-inch height. This prevented turf growth beyond about 2½ inches, except for Bermudagrass inflorescence.

Results and Discussion

Wild garlic control data at various stages during repeated herbicide treatments are reported in Table 1. The number of garlic shoots was reduced 83 percent or more by one application of 2,4-D or MH, which was somewhat better control than previously reported (2,3). These treatments were standard for evaluating dicamba and substituted oleyl amine formulations of phenoxy herbicides.

Table 1. Wild garlic control following repeated herbicide treatments on March 26 and November 20, 1963, and March 26, 1964, respectively (average 3 samples per plot and 4 replications).

Herbicide	Each application rate lb/A	Garlic shoots per sq ft 11/20/63	Garlic bulbs in core of soil 6" dia.x 5" deep 5/13/64	Garlic bulbs in core of soil 4" dia.x 5" deep 10/21/64
2,4-D, butoxy-ethanol ester	2	7	2	0
2,4-D, OPDS	2	12	8	0.6
silvex, dimethyl-amine salt	2	25	14	2
dicamba	2	17	2	0.6
MH	4	4	16	0
check	-	41	82	58

Soon after the third treatment, dicamba and 2,4-D were equally effective for reducing the number of wild garlic bulbs in the soil. At this time silvex and 2,4-D, OPDS had reduced bulb populations by 83 percent or more. Silvex, OPDS appeared inferior to other treatments. Some of the bulbs were affected and appeared soft at this time. Later evaluations indicated that a number of affected bulbs did not remain intact through the summer of 1964. In comparison to the untreated check, dicamba, 2,4-D, MH, and 2,4-D, OPDS reduced the wild garlic bulb population by 99 percent or more. Silvex, OPDS gave 84 percent reduction in bulb numbers and appeared to be less effective than other treatments.

Other weeds present in the experimental area in the beginning included Veronica sp., Trifolium repens L., Stellaria media L., and Lamium amplexicaule L. Variable control of these weeds was obtained with these treatments. The herbicides were placed in the order of decreasing effectiveness on these weeds as follows: dicamba, 2,4-D, silvex, 2,4-D, OPDS, MH and silvex, OPDS.

The response of Bermudagrass turf to repeated treatments of these herbicides was also recorded (Table 2). The weights of Bermudagrass in 4-inch plugs was increased considerably by effectively removing wild garlic and other weeds from this turf.

Table 2. Bermudagrass response following repeated herbicide treatments for wild garlic control (average 3 samples per plot and 4 replications).

Herbicide	Each application rate lb/A	Weight (g) of bermudagrass in core of soil 4" diameter by 5" deep - 10/21/64
2,4-D, butoxyethanol ester	2	21
2,4-D, OPDS	2	23
silvex, dimethylamine salt	2	20
silvex, OPDS	2	10
dicamba	2	20
MH	4	18
check	-	13

Summary

Wild garlic was effectively controlled with repeated treatments of 2,4-D, 2,4-D, OPDS, dicamba and MH. Through control of wild garlic and other weeds in Bermudagrass turf, the quality and quantity of turf was improved.

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PRE- AND POST-EMERGENCE EFFECT OF 1-(2-METHYLCYCLOHEXYL)-3-PHENYLUREA ON CRABGRASS AND FIVE TURFGRASS SPECIES.

J. M. Duich, W. G. Downs and B. R. Fleming[1]

During the last decade the objective of pre-emergence crabgrass control research has been the development of a selective herbicide with a high level of control, non-toxicity to various permanent turfgrass species, even when handled by an amateur, and a duration period of approximately one growing season. Considerable success toward these ends has suddenly sophisticated the objectives to include post-emergence properties, safety to seedling turfgrasses at various stages of development and most recently selectivity in the seedbed.

Recent studies (1,2,3,4,5,6,7) have shown that only a partial degree of success can be achieved with such a herbicide on seedling turf or in the seedbed. In general, the most effective herbicides persist the longest in the soil, have a narrower turfgrass tolerance and are most detrimental to seedling turf. Conversely, those herbicides showing the broadest mature and seedling turf tolerance result in variable level weed control and persist for much shorter periods.

Based on preliminary private greenhouse and field data (8) and a greenhouse screening by Klingman (9), a pre- and post-emergence field study was conducted with the experimental herbicide H-1318, 1-(2-methylcyclohexyl) -3-phenylurea.[2]

Materials and Methods

The study was conducted on a Hagerstown silt-loam soil at University Park, Pa., beginning in May 1964. The area was successfully "sterilized" with methyl bromide on May 20, 21 to eliminate undesired vegetation. Seedbed was prepared with 50 lbs./M of 10-5-5 (70% UF, 30% natural organic nitrogen) fertilizer surface raked on May 26, except for those areas to receive herbicide treatment on a fertilizer carrier.

Grasses were seeded in triple replicated strips as follows: crabgrass (Smooth and Hairy) at 1.5 lbs./M, bent (Highland and Astoria mixed) at 1.0, Kentucky bluegrass at 1.8, Merion bluegrass at 1.8, redtop at 1.3 and Pennlawn red fescue at 3.5. The grasses were seeded individually in 3 x 72 ft. strips and herbicide or control treatments placed perpendicularly across the six grasses 3 x 18 ft. in each replication. Individual treatments per grass were 3 x 3 ft.

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[2] Trademarked "Tupersan" - DuPont Company

Herbicide formulations consisted of a wettable powder, two on vermiculite carrier and one on a fertilizer carrier. The wp treatment was applied with a boom plot sprayer at 35 psi, 100 gpa and dry treatments by hand after diluting with eight quarts of very dry sterilized soil. Plots were then uniformly covered with sterilized soil at $\frac{1}{4}$" loose depth applied with a Root topdresser, firmed with roller and spray-mulched with Soil-Guard. This type of mulching was applied to allow use of sprinkler irrigation and to prevent lateral surface movement of seed or herbicide.

The seeding and herbicide treatments were applied on May 27 with each formulation applied at 4.5, 6.75, 9 and 13.5 lbs. a.i/A plus two re-run formulations at 4.5. Post-emergence treatment area was established as above, except that single date herbicide treatments were made on June 17, July 3 and July 17.

Soil was dry to a 2" depth during establishment operation. Water was applied on May 29 and moisture carefully maintained until June 14 to aid in optimum germination and seedling establishment. Although irrigation frequencies were thereafter lengthened, it should be noted that the experiment was not subjected to prolonged moisture stress during the season.

Results and Discussion

Pre-emergence Test. Germination was observed as follows: bent and redtop June 2, fescue June 4, both bluegrasses June 6 and crabgrass June 7. The only delay in germination due to the herbicide treatment was on the crabgrass and only by two-three days. All grasses, including crabgrass, showed a uniform degree of germination compared to control plots.

However, the crabgrass seedlings in treated plots turned bluish in two days and began to redden after seven. With few exceptions, their leaves never exceeded a length of approximately $\frac{1}{2}$" and root growth was limited to the radical only, at a maximum length of $\frac{1}{4}$" with no branching as observed in control plots. The two-leaf stage was reached by less than 25 percent of the seedlings at the lower 4.5 and 6.75 rates. The stunted seedlings began to brown and wither on June 22, proportionately to rate, and disappeared by July 1 except for the relatively few survivors.

The effects of the pre-emergence herbicide treatment at various rates for the four formulations are shown in Table 1. Based on the mean control stand of 2808 crabgrass seedlings per nine square foot plot, all treatments were found to be 99+ to 100 percent effective on June 26. A further reduction in survival was noted by August 30. There was no substantial difference between formulations, but control increased somewhat proportionately with application rate.

The turfgrasses were observed to turn slightly bluish and somewhat stunted in foliar growth approximately a week after emergence. Bent and redtop, due to their more rapid and upright seedling growth, were measured prior to initial mowing. Compared to check plot heights of 3.5 and 5.4 inches for bent and redtop, the herbicide treatments reduced growth from 15 to 50 percent, and 10 to 20, respectively. This effect was measured at approximately 16 days after emergence and was not apparent after an additional 12 days.

The stunting and discoloration effect was also noted on the two bluegrasses and red fescue. Since they were slower growing, slightly decumbent and visual ratings proved unsatisfactory, all grasses were plug sampled by treatment on July 10 and frozen. Sampling took place during the period that all treatments appeared recovered to "normal". Root weight to three inch depth, top weight and stand counts are being determined, but are incomplete due to the tedious nature of the analyses. Subsequent observations indicate no lasting inhibiting effect, particularly when the experimental area was allowed to dry to the early wilting stage.

In October, representative plots were plug sampled to a six inch depth and divided into two-inch zones for a greenhouse bio-assay test. Crabgrass, obvicusly, is being used as the index species to determine the possible location and persistence of the herbicide after five months. The incompleted data should be most useful in supporting the present evidence of a most promising seedbed herbicide.

Post-emergence Test. Post activity on crabgrass was immediately observed to be quite slow compared to conventional herbicides. Treated plots showed no effect for 6-8 days, then turned blue and progressively purplish (similar to the anthocyanin pegmentation of a maturing corn leaf) to brown, depending upon treatment date and rate. However, upon reaching the soil the herbicide appeared to affect roots severely. Existing roots deteriorated rapidly and secondary roots initiated from the perimeter of the crabgrass crown. These roots were abnormally thicker, straight, non-branching (root hairs appeared absent) and approximately three-quarter inches long. A characteristic of a treated crabgrass plant, regardless of size, is that it can be easily plucked from the soil.

The results of the post-emergence treatments at three single application dates are shown in Table 2. Visual estimates of percent control following treatment proved difficult due to the nature of herbicide activity, particularly on a "pure" crabgrass stand. Given estimates were therefore based on density compared to control plots.

Following heavy frosting in October, representative crabgrass plots were sampled with an eight-inch plugger. Results are shown in Table 2 as plant dry weight and plant population count, percent reduction based on controls, respectively, average weight of surviving plant and check: treatment plant weight ratio.

These data collectively indicate that post-emergence herbicide activity decreases with increased age of crabgrass. While none of the rates used in the study completely controlled crabgrass with a single application, activity for each of the above criteria was influenced by rate and/or date of application. The greatest reduction in crabgrass top weight was obtained from the June 17 application, followed by an appreciable activity drop from the July 3 treatment. The third date application on July 23 proved to be of minimum effectiveness. The wp formulation was slightly more effective than the 10-5-5 fertilizer formulation.

The rate and date of application effect on the plant stand number was similar to the results on top growth except that the July 3 treatment results were only slightly less effective than those obtained from June 17.

On the basis of the average weight of one surviving plant or the check: treatment plant weight ratio it was generally found that surviving plants continued to increase as within plot competition was reduced. This measurement appears to be correlated with top dry weight and stand count. It can only be speculated that unaffected turfgrass competition in a mixed grass-crabgrass stand would reduce the size of the treated crabgrass plants.

Seed was collected from treated and control plots in October for study on the possible effect of the herbicide on formation. No differential seed-set or panicle abnormalities were observed, although seed appeared to be somewhat immature following the heavy frosting period in early October. The test area was subjected to a light frost on September 13 and a heavy discoloring frost the following day which may have affected seed formation. Unseasonably warm weather followed in September and renewed limited root growth and firmer anchoring was surprisingly noted on September 30. Some top growth was also re-initiated in the last week of September on the lighter rate and July 23 treatment plots.

In view of the selective seedbed and post-emergence properties of H-1318, the mode of herbicide action becomes of practical interest. Post crabgrass seedling mortality, root deterioration and inhibition, and delayed foliar activity in post-emergence application point to root absorption. Additional information is needed on surface stability, effect of moisture on soil and plant movement, residual properties, moisture stress particularly on desired species and effectiveness of multiple applications at lighter rates for post-emergence crabgrass control. It is the object of the uncompleted portions of this study to aid in the understanding of several of the above questions.

Conclusions

The herbicide, 1-(2-methylcyclohexyl)-3-phenylurea, was field evaluated on crabgrass and five turfgrass species when applied at the time of seeding and for post-emergence activity at several dates. Four formulations, including a wettable powder and three dry carriers were applied at rates of 4.5, 6.75, 9.0 and 13.5 lbs. ai/acre.

Pre-emergence:

1. Although crabgrass actually germinated, development was limited to a severely stunted one- or two- leaf stage with a maximum leaf length of approximately one-half inch. In excess of 99 percent control was obtained at the lowest rate. No differential formulation effect was noted.

2. The herbicide did not appear to effect the germination or emergence of five turfgrass species. Subsequent foliar growth was inhibited, proportionately to rate, for approximately three weeks.

3. In view of the crabgrass selectivity and subsequent recovery and normal growth of the turfgrasses under the conditions of this study, the herbicide is considered to be a potentially valuable management chemical.

Post-emergence

4. The herbicide exhibited post-emergence properties when applied to a pure crabgrass stand, generally proportionate to rate and date of application. Although none of the rates completely controlled crabgrass with a single application, root, topgrowth and plant stand were significantly reduced.

5. Root absorption activity mode is suggested on basis of post crabgrass seedling mortality, root deterioration and inhibition and delayed foliar activity from post application.

6. Areas requiring additional investigation are suggested on the basis of results and observations of this study.

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Table 1. Effect of herbicide H-1318 on crabgrass survival and permanent turfgrasses when applied at time of seeding, May 27, 1964.

Formulation	a.i./ Acre	Crab. Plants /9 Sq. Ft. 6/26*	8/30*	Ht. in Inches Prior 1st Cut Bent	Redtop	Merion, Ky. Blue & Fescue**
50W	4.5	15.7	10.7	3.0	5.1	
	6.75	2.0	0.3	3.0	4.3	
	9.0	0.7	0.3	2.7	4.1	
	13.5	0.3	0	2.7	4.1	
# 6-Verm	4.5	17.7	8.7	3.0	4.9	
	6.75	6.3	2.3	2.7	4.7	
	9.0	3.3	1.3	2.2	4.2	
	13.5	0	0	1.9	4.1	
# 7-Verm	4.5	19.7	12.0	3.0	4.8	
	6.75	3.3	0.7	2.9	4.7	
	9.0	3.3	1.0	2.2	4.2	
	13.5	0	0	2.2	4.2	
# 7-1	4.5	9.3	5.7	3.0	4.3	
10-5-5***	4.5	10.7	4.3	2.2	2.9	
	6.75	5.7	3.0	1.4	3.2	
	9.0	1.0	0.3	1.4	2.7	
	13.5	0	0	1.4	2.7	
10-5-5 #2	4.5	25.0	11.3	1.9	3.3	
Control ($\bar{x}$ of 18)		2808.0	----	3.5	5.4	

* All crabgrass plants in treated plots were stunted or injured to some extent and had reduced root growth.

** Merion, Ky. blue and Fescue were affected by bluish color and morphological stunting for approx. three weeks. Species showed normal growth thereafter. July sampling made and frozen for comparative top, root and stand analyses. Data not yet completed.

*** It should be noted that the lower initial growth for the 10-5-5 series on bent and redtop is due to lower seedbed fertilization.

Table 2. Post-emergence effect of H-1318 on May-seeded crabgrass* from single treatment application at three dates. October data expressed as average sample dry weight, average sample plant count, average weight of one plant, check: treatment plant weight ratio and estimated percent control.

Treatment & Date Form.	ai/A	Ave sample dry wt gms	% Reduction**	Ave sample plant count	% Reduction**	Ave wt one plant gms	Check: Treatment Plant wt ratio**	Estimated % control***
June 17								
10-5-5	4½	16.90	14.6	149.50	37.6	0.1150	1.337	20
	9	14.40	27.3	109.50	54.3	0.1315	1.529	60
	13½	9.15	53.8	69.30	71.1	0.1320	1.534	75
	18	9.20	53.5	70.20	70.71	0.1435	1.668	85
50W	4½	15.15	23.5	205.35	14.3	0.0765	0.889	20
	9	13.45	32.1	94.80	60.4	0.1460	1.697	60
	13½	10.75	45.7	59.85	75.0	0.1870	2.174	75
	18	6.55	66.9	40.15	83.2	0.1540	1.790	95
July 3								
10-5-5	9	15.80	20.2	135.65	43.4	0.1350	1.569	25
	18	15.45	22.0	75.80	68.4	0.2140	2.488	75
50W	9	14.15	28.5	99.30	58.6	0.1595	1.854	20
	18	12.05	39.1	69.15	71.1	0.1755	2.040	70
July 23								
10-5-5	9	24.35	-23.0	218.15	9.0	0.1180	1.372	10
	18	21.55	- 8.8	235.85	1.6	0.0895	1.041	40
50W	9	17.60	11.1	186.50	22.2	0.0980	1.139	10
	18	19.25	2.9	222.15	7.3	0.0950	1.105	40
Controls	---	19.80	----	239.70	----	0.0860	-----	--

* Permanent turfgrass species slightly stunted by June 17 treatment only, recovered normally.
** Based on control plots.
*** % Control estimates based primarily on "density" compared to control plots.

Problems in Merchandising Turfgrass Herbicides

Harold A. Duyser[1]

After reviewing several copies of the Proceedings of the Northeast Weed Control Conference, it was learned that this is the first time industry has been given the opportunity to express its views regarding the marketing of herbicides.

This also gives industry the opportunity to express its gratitude to those dedicated people associated with the research and evaluation of the various herbicides.

Many important developments have taken place since the discovery of 2,4-D in 1942 by Drs. Zimmerman and Henderson at the Boyce Thompson Institute. This event opened up an entirely new field which has resulted in immeasurable economic and aesthetic benefits. Since the discovery a myriad of herbicides have been developed for use in horticultural and agronomic crops, highway brush control, industrial weed and brush control, aquatic weed control, and with no less important contributions to the control of weeds in turf.

With the continuing increase of turf acreage, herbicides for the control of turf weeds are being developed at an unprecedented rate. These are being offered as replacements to those in current use or in combination with other herbicides for broad spectrum control. From those offered, a relatively few will maintain a dominant position in the market place. This is partly because of poor control or the incidence of turf injury. Others could fail through causes directly attributable to the lack of follow through in the merchandising program.

Some time ago a sales manager from one of our major industries gave a talk relating to the importance of follow through in merchandising. He demonstrated how the handling of product information, passing from research to development, advertising to sales, and from the distributor to the consumer is too often paralleled with filling a leaky pail with water; full at the research level, 3/4 full after advertising, 1/2 full after sales, 1/8 full at the distributor level, and 1 drop to the consumer.

This was exaggerated, of course, but how many products which would have enjoyed a popular position in addition to serving as valuable tools were rejected because somewhere along the line someone failed to follow through. It would not be prudent to point to specific cases, but all too often this has happened, and it is being perpetuated every day.

1 Manager, Special Products Department, The Hubbard-Hall

When a herbicide is developed and appears to be worthy of a position in the market, the supporting data should follow through to all those involved in its merchandising and use. This should be insisted upon by the manufacturer.

At the advertising level every effort should be made to include as much vital information as is necessary to insure that the product will be used as intended. If this cannot be stated on the label, a separate brochure should be made available covering such information as specific rates, time of application, type of equipment, calibration, and whatever other information is necessary for correct application.

If the chemical is combined with other materials for double or triple action benefits, consideration should be given to the individual benefits of each material - and should not be sold on the basis of coverage alone.

The salesman's role in marketing, to provide the link between the manufacturer and the distributor, or from the distributor to the consumer, is one of extreme importance. Unless a salesman is prepared to identify the problem and to offer a solution, he is putting his product and often his company in jeopardy. All pertinent information covering the product must be available to him, and today, more than ever before, he must do his homework well.

With the cost at each level of merchandising at an all time high, nothing can be taken for granted. Only when we bring the full measure to the consumer can we accomplish the desired end result he expects, and, contrary to some current thinking, he is willing to pay the price

A NEW HERBICIDE FOR THE SELECTIVE CONTROL OF ANNUAL SEEDLING WEED GRASSES IN TURF AND CROPS

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E. I. du Pont de Nemours & Company, Inc.
Wilmington, Delaware

INTRODUCTION

1-(2-Methylcyclohexyl)-3-phenylurea[2] shows promise as a new chemical tool for use in the selective control of certain annual seedling weed grasses. This herbicide has unique characteristics which make it an obvious candidate for the control of some undesirable grasses in turf and for many crop applications where annual grasses are an important part of the weed problem.

An outstanding feature of 1-(2-methylcyclohexyl)-3-phenylurea is its truly selective preemergence elimination of several annual seedling grasses from other grasses. It has been shown, for example, that treatment at the time of seeding a new turf will control crabgrass (*Digitaria ischaemum* and *D. sanguinalis*) and some other annual grasses[3] without causing injury to germinating seeds of common temperate-region turf species. The extent of the tolerance of desirable turf grasses has been demonstrated most strikingly by the successful dry application of mixtures of turf seed and chemical to a prepared seedbed. Such applications have controlled annual weed grasses yet permitted the normal establishment of the new turf.

The selective control of some grasses with safety to seeds and seedlings of other grasses also extends to field crops. Applications preemergence to the crop have controlled such weeds as crabgrass, foxtail (*Setaria viridis* and *S. lutescens*) and downy brome (*Bromus tectorum*) without significant injury to some

[1]Contribution from Industrial and Biochemicals Department, Experimental Station, E. I. du Pont de Nemours & Company, Inc.

[2]The active ingredient in Tupersan™ Weed Killer.

[3]Annual bluegrass (*Poa annua*) has not been controlled at any stage of growth.

cereals. Expanded evaluation may disclose other instances of the beneficial removal of one grass from a planting of another.

A second distinctive characteristic of 1-(2-methylcyclohexyl)-3-phenylurea is its wide margin of safety on a great number of broadleaf crops. Thus, this material merits consideration in situations where susceptible annual grasses represent the critical problem or where broadleaf weeds can be removed by some other means.

Another unusual effect is the differential retarding or stunting of annual grasses when the chemical is applied postemergence or preemergence at sub-lethal rates. This response appears to be due to inhibited root growth which leaves the affected weeds poorly equipped to stand the effects of drouth or competition.

TOXICITY INFORMATION

Acute oral toxicity of 1-(2-methylcyclohexyl)-3-phenylurea for the white male rat is low, its Approximate Lethal Dose (ALD) being greater than 5000 mg/kg of body weight.

A 50% wettable powder exhibited low cumulative oral toxicity when administered to male rats at the extremely high rate of 3400 mg/kg/day of active ingredient for a total of ten doses.

The active ingredient was fed to male and female albino rats for 95 to 97 days at levels as high as 5000 to 7500 ppm (dietary level raised to the higher concentration after six weeks) in an adequate diet without nutritional or clinical evidence of toxicity. There was evidence from blood examinations of a slight anemia, but this was observed only in male rats fed the highest dietary level. Organ weight measurements and histological examination of tissues from animals that received the highest level disclosed no significant change attributable to the chemical.

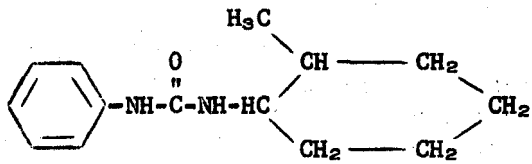
Two-year feeding tests with rats and dogs are in progress.

When either 10 mg of a 50% wettable powder formulation or 0.1 ml of a 10% suspension in propylene glycol was introduced into rabbits' eyes, the reactions were no greater than those that would result from the introduction of an inert material

The material was not irritating to guinea pig skin during prolonged contact as a 10% suspension in dimethyl phthalate. As a 25% suspension it was mildly irritating, as a 40% suspension it was moderately to strongly irritating. It did not, however, produce an allergic contact dermatitis.

PHYSICAL AND CHEMICAL PROPERTIES OF ACTIVE INGREDIENT[1]

Structural Formula:



Physical Form:	White, crystalline solid.
Molecular Formula:	$C_{14}H_{20}N_2O$
Molecular Weight:	232.32
Melting Point:	133 - 138°C.
Odor:	None.

Solubility in water at 25°C: 18 ppm

Solubility in organic solvents: Soluble to the extent of 10% or more in ethyl alcohol, Cellosolve®, dimethyl formamide, dimethyl acetamide, methylene chloride and isophorone.

K value in Keyport silt loam: 2.5[2]

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[1]Available as a free-flowing wettable powder containing 50% by weight of 1-(2-methylcyclohexyl)-3-phenylurea.

[2]K value = ppm of herbicide adsorbed on soil (air-dry basis) which is in equilibrium with an aqueous solution containing 1 ppm of herbicide at 25°C.

USE ON TURF AND CROPS

Annual Grass Control in Turf

The unusual safety margin of this compound on a number of important sod grasses makes it an outstanding candidate for use on lawns, golf courses and other turf areas. The degree of safety is illustrated by the fact that seed of common types of Kentucky bluegrass (*Poa pratensis*), red fescue (*Festuca rubra*) and bentgrass (*Agrostis* sp.) have germinated and grown in soil containing eight times as much of the new compound as was required to control unwanted annual grasses such as crabgrass and foxtail (Table 1). This unprecedented tolerance permits pre-emergence use in the planting of new lawns as well as complete freedom in reseeding parts of existing lawns either before or after treatment.

In planting a new turf, soil preparation and seeding should be done in the usual manner and the herbicide applied immediately at rates in the range of 2 to 6 pounds of the active ingredient per acre. (The lower rate is used for sandy soils and the higher rate for soils containing high levels of clay or organic matter.) Areas which receive 2 to 3 pounds should be retreated about one month later with an additional 2 to 4 pounds of active ingredient per acre to provide control until the end of the season. Any watering program that will promote uniform germination and establishment of the turf stand should be adequate for optimum performance of the chemical.

Applications to established turf are most effective if made prior to the germination of the annual weed grass species to be controlled (Table 2). Treatment just after a mowing and during the month preceding the earliest expected germination of the weed grasses has been satisfactory. Rates of 8 to 12 pounds (active) per acre have been adequate for full-season control, with the higher rates being required on heavier soil types or soils high in organic matter. These rates may be employed even where the turf contains areas recently planted or where there might be plans for prompt subsequent reseeding.

Results may be disappointing in an established turf if at least one-half inch of water is not received between the time of treatment and the germination of the weed grasses. Best results have been obtained when rainfall or irrigation followed

treatment within three to four days. Where applications are made late (i.e., near time of germination), it may be desirable to irrigate promptly to assure that the chemical moves into the soil sufficiently to control early germinating weed grasses.

A necessary feature of a turf herbicide is that it be safe to trees and other ornamental plants. Applications of 120 pounds active per acre to plots with trees and 40 pounds per acre to plots with representative ornamental shrubs and vines for two consecutive years have given no injury.

Seedling Grass Control in Crops

In evaluating 1-(2-methylcyclohexyl)-3-phenylurea, it should be remembered that this material is a useful tool for the control of certain grasses growing from seed but that it has very limited activity on broadleaves.[1] In general, the evaluation of the new material is suggested for two weed situations: (1) where seedling grasses are the limiting factor or (2) where broadleaf species present in a mixed weed population can be removed by other means. Methods of removing broadleaf weeds which may be employed in conjunction with the new compound include other chemicals or physical roguing.

Safety to most broadleaf crops is such that applications could be made both preemergence and then again after any mechanical cultivation necessary for the removal of broadleaf weeds. For those crops in which present production practice involves hand weeding, the cost of this operation could be greatly reduced by preventing the development of many of the grasses with the new chemical.

Applications are most effective if made preemergence to the seedling grass weeds to be controlled. Necessary use rates increase with the colloidal and organic matter content of the soil. Suggested levels for normal preemergence applications are:

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[1]Two to four pounds per acre will provide preemergence control of some broadleaf species including purslane (*Portulaca oleracea*) and lambsquarters (*Chenopodium album*).

Lb (Active) Per Acre	Soils
2 to 3	Sandy and sandy loam soils.
4 to 6	Heavier soils low or medium in organic matter content.
6 to 10	Soils with sufficient organic matter to impart a dark color.

Grass weeds that have been controlled by such applications include crabgrass, downy brome, foxtail (including *Setaria faberii*), barnyardgrass (*Echinochloa crusgalli*), witchgrass (*Panicum capillare*), Johnsongrass (*Sorghum halepense*; from seed only) and nimblewill (*Muhlenbergia schreberi*; from seed only).

Normal preemergence applications are effective in controlling weed grasses only if the active ingredient is carried to the depth of the germinating weed seeds. Treatments have generally been successful if one-half inch or more of rainfall or irrigation water reaches the soil within three to four days. Mechanical incorporation of the chemical into the soil may be useful where water cannot be relied upon to provide the necessary downward movement. The incorporation procedure should be generally such as to retain the chemical in the top one-half inch. If deeper incorporation is employed, suggested use rates should be increased to compensate for the dilution effect.

Postemergence applications, although less effective in eliminating weed grasses, do have a marked stunting effect on young seedlings of many grasses and may be useful under some circumstances. Stunted seedlings often are not an important factor in competition subsequently and, due to greatly restricted root growth, may fail to survive even brief periods of water shortage. Also, they are much easier to remove by mechanical means as a consequence of the poorer anchoring.

The pattern of soil disappearance has been studied over a three-year period on field plots situated in a temperate climate (lat. 40° north) under an annual rainfall of about 45 inches. There has been no evidence of residual chemical in the soil after one year even with applications much in excess of those required for weed control.

TABLE 1. ANNUAL GRASS CONTROL BY APPLICATIONS PREEMERGENCE TO NEW TURF SEEDINGS NEWARK, DELAWARE[1]

Rate Lb/A (Active)	% Control of Annual Grasses[2] After 5 Months	Injury Rating on Turf After 1 Month		
		Bent	Fescue	Ky. Blue
2 + 2[3]	97	0	0	0
4	98	0	0	0
6	100	0	0	0
8	100	0	0	Trace
16	100	0	0	0

[1]Newly prepared site on Butlertown silt loam seeded with both crabgrass and turf grasses on April 25 and treated the same day.

[2]Included crabgrass and yellow foxtail.

[3]The second application of two pounds was made approximately one month after the first.

TABLE 2. CRABGRASS CONTROL IN ESTABLISHED TURF WITH APPLICATIONS ON VARIOUS DATES NEWARK, DELAWARE

Rate Lb/A (Active)	% Crabgrass Control in September			
	4/3[1]	4/18[1]	5/3[1]	5/17[1]
4 + 4[2]	97	-	-	-
6	97	99	92	93
9	97	97	100	100
12	100	100	100	100
20	100	100	100	100

[1]Dates of application on a Butlertown silt loam. On untreated areas, crabgrass germination started in mid-May and continued with the major portion taking place in June.

[2]Four pounds applied each on April 3 and May 3.

SELECTIVE HARDWOOD CONTROL WITH 4-AMINO-3,5,6-TRICHLOROPICOLINIC ACID.

John L. Arend[1/]

A new systemic herbicide, 4-amino-3,5,6-trichloropicolinic acid, identified by the manufacturer as Tordon,[2/] is effective in controlling many northeastern hardwoods. This herbicide is formulated as the potassium salt which is highly soluble in water and is available both as pellets (Tordon 10K) and as a liquid (Tordon 22K). Tordon 101 Mixture containing Tordon and 2,4-D as the triisopropanolamine salt is also available. Tordon therefore can be applied by various methods as pellets for spot and broadcast treatments, diluted in water for foliage sprays, or used in concentrated solutions in basal cut surfaces. According to the manufacturer, Tordon is non-corrosive to equipment and low in toxicity to man and other animals.

During the past 2 years we have studied the comparative effects of Tordon 22K and Tordon 101 Mixture along with a triethylamine salt of 2,4,5-T applied by basal injections to oak and other mixed hardwoods in Lower Michigan. This paper presents our results with Tordon in basal injection applications and offers some general prescription guides for its use in tree injectors for the selective control of many hardwoods found in the northeastern portion of the United States.

Field Methods

Species:--Our basal cut surface experiments were conducted mainly on red oak (*Quercus rubra* L.) and white oak (*Q. alba* L.) growing on very productive sites (site index 80+) in southern Michigan. We also applied a few Tordon treatments on many other hardwoods including hickory (*Carya* sp.), red maple (*Acer rubrum* L.), sugar maple (*A. saccharum* Marsh), beech (*Fagus grandifolia* Ehrh.), eastern hophornbeam (*Ostrya virginiana* Mill.), boxelder (*Acer negundo* L.), elm (*Ulmus americana* L.), black cherry (*Prunus serotina* Ehrh.), and white ash (*Fraxinus americana* L.), and on one conifer, eastern red cedar (*Juniperus virginia* L.). These trees ranged from about 5 to 16 inches at d.b.h.

Herbicides:--Tordon 22K is a 2-lb. acid equivalent gallon containing 21.5 percent 4-amino-3,5,6-trichloropicolinic acid as the potassium salt. Tordon 101 Mixture contains Tordon at .54 lb. a.e. gal. and 2,4-D at 2 lb. a.e. gal. as the triisopropanolamine salt. A standard commercial phenoxy

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1/ Project Leader, Silviculture of Mixed Hardwoods, Lake States Forest Experiment Station, Forest Service, U. S. Dept. of Agr. He is headquartered at the Station's East Lansing, Michigan, field office which is maintained in cooperation with Michigan State University.

2/ Manufactured by Dow Chemical Company.

herbicide, the triethylamine salt of 2,4,5-T containing 4 lb. acid equivalent gallon which was diluted with water to a 2 lb. a.e. gal. solution, was tested along with the two Tordon formulations.

Spacing of injections and volume of herbicide per injection:--The injection incisions were 2 inches wide and were spaced 2, 4, and 6 inches apart (edge to edge). They were made with a 2-inch wide chisel. These incisions were generally 1/2-inch deep, but all were deep enough to hold the volume of herbicide applied.

The herbicide was applied in undiluted volumes at rates varying from 1/4 ml. to 8 mls. per injection depending on the herbicide formulation. We tried to test the minimum and maximum volumes that might be effective for the particular herbicide. A graduated automatic pipette was used to measure the volume of herbicide applied to each injection cut. This precision method of applying the treatments can be easily simulated with commercially available tree injectors.

Season of year or stage of growth:--These treatments were tested at different months of the year for their effects at different stages of growth as follows:

1. Early dormancy (October)
2. Late dormant season (March)
3. Peak of the growing season (mid-June)

Results

The toxic effects of Tordon on woody plants appear to be similar to those caused by 2,4-D and 2,4,5-T. The initial visible reaction is wilting and curling of the leaves during the growing season followed by browning and fall of the foliage. Trees treated by cut surface application in the fall often fail to leaf out the next spring. There is some rupturing of the stem (callus-like growth) near and above the cut surface applications. This stem injury is more noticeable on white oak than other hardwoods.

Most trees injected with Tordon show top-killing effects the first growing season after treatment. Those showing 60 percent top kill (more than half of crown or foliage dead) the first growing season after treatment will normally die the following years. We have found no exceptions to date. However, trees showing 50 percent or less top kill the first growing season after treatment cannot be safely assessed for control until the second year. Occasionally a tree with an estimated top kill of 50 percent the first year -- especially with 2,4,5-T will show less top kill the following year. In such trees, the unkilled portions of the cambium where the basal injections were made start to heal over, the crown enlarges, and the tree may live for many years.

Tordon was about equally effective in basal injection applications on oaks during both the dormant and growing seasons. In contrast, the triethylamine salt of 2,4,5-T was at least twice or more as effective on oaks when applied during the peak of the growing season as at other seasons of the year.

Our 1963 March and June treatments suggest that 1/4 ml. to 2 mls. of undiluted Tordon 22K per injection covers the range of its effectiveness on oak at spacings of 4 to 6 inches. At 2-inch spacing, 1/4 ml. of Tordon per injection may overkill the size oak we treated because 100 percent control was constantly obtained (Table 1).

The 1 ml. and 2 ml. volumes of 2,4,5-T per injection were effective on red oak only during the peak of the growing season at 2-inch spacings.

Red oak was also found to be slightly more difficult to control by basal injection of these herbicides than white oak (Table 1). However, the crowns of the red oak averaged slightly larger than those of white oak. Therefore, we do not know if this difference in herbicide resistance is related to species or crown size.

Our 1963 October and 1964 June treatments were continued mainly on red oak, using Tordon 22K at the same rates per injection, and 2,4,5-T in larger volumes to determine effective dosages. Tordon 101 Mixture was also tested at volumes of 1/2 ml. to 8 mls. per injection.

The results of the injection treatments by spacing intervals may be summarized as follows:

2-inch spacing of the injections:--1/4 ml. of Tordon resulted in 100-percent control of oak after two growing seasons regardless of the season of the year that it was applied (Tables 1 and 2). For similar control with Tordon 101 Mixture about 1 ml. was required per injection. The triethylamine salt of 2,4,5-T required 1 ml. per injection during the peak of the growing season (mid-June) and about 4 mls. per injection at other seasons of the year.

4-inch spacing of the injections:--1/2 ml. to 1 ml. of Tordon was required for effective control of red oak. Similar control was obtained with 1 to 2 mls. of Tordon 101 Mixture and 4 to 6 mls. of 2,4,5-T amine.

6-inch spacing of the injections:--1 ml. of Tordon per injection appears adequate for the control of oak (Tables 1 and 2). Similar control was obtained with 2 mls. of Tordon 101 Mixture. The amine salt of 2,4,5-T was ineffective at this spacing on oak except during the peak of the growing season which required 8 mls. per injection.

No sprouting of the top-killed trees by these basal injection treatments has developed after two growing seasons.

Discussion of Results

Species resistance:--Our studies on species resistance to Tordon and 2,4,5-T were confined mainly to white oak and red oak (Table 1). We found red oak to be slightly more resistant to those herbicides in tree injection treatments than was white oak growing under similar conditions. Our experience suggests that the injection treatments that will control vigorously growing red oak on very productive sites will also control most other oak species in the northeastern regions of the United States.

Table 1.--Effects of Tordon[1/] and 2,4,5-T[2/] in basal injection applications on the control of white and red oak.

Injection and Herbicide	Volume Per Injection	Treated March 1963				Treated June 1963			
		White Oak Controlled by		Red Oak Controlled by		White Oak Controlled by		Red Oak Controlled by	
		August 1963	August 1964	August 1963	August 1964	August 1963	August 1964	August 1963	August 1964
	Mls.	Percent							
2-inch spacing									
Tordon 1/	¼	100	100	100	100	100	100	80	100
"	½	100	100	100	100	100	100	100	100
"	1	100	100	100	100	100	100	100	100
2,4,5-T 2/	1	20	20	0	0	100	100	0	100
4-inch spacing									
Tordon	¼	60	60	40	40	0	80	0	80
"	½	100	100	60	60	100	100	100	100
"	1	100	100	100	100	100	100	100	100
"	2	100	100	100	100	--	--	--	--
2,4,5-T	1	40	60	0	0	20	100	40	60
"	2	0	20	0	0	--	--	--	--
6-inch spacing									
Tordon	¼	40	100	20	20	0	20	0	40
"	½	80	100	80	80	100	100	80	100
"	1	100	100	100	100	100	100	80	100
2,4,5-T	2	60	100	40	60	--	--	--	--
"	1	0	20	0	0	0	0	20	60
	2	0	60	0	0	--	--	--	--

1/ 4-amino-3,5,6-trichloropicolinic acid as the potassium salt, 2 lb. a.e. gal.

2/ Triethylamine salt of 2,4,5-T diluted with water to 2 lb. a.e. gal.

Table 2.--Effects of 2,4,5-T, Tordon, and Tordon mixed with 2,4-D on control of red oak by basal injections.

Injection Spacing and Herbicide	Volumes Applied Per Injection	Date Treated			
		March 1963	June 1963	October 1963	June 1964
	Mls.	Percent of Trees Controlled by 8/64 1/			
2-inch spacing					
2,4,5-T 2/	1	0	100	0	80
"	2	--	--	60	100
"	4	--	--	100	100
Tordon 3/	¼	100	100	100	20
"	½	100	100	100	100
"	1	100	100	100	100
Tordon Mixture 4/	½	--	--	60	60
"	1	--	--	100	80
"	2	--	--	100	100
4-inch spacing					
2,4,5-T	1	0	60	--	--
"	2	0	--	0	40
"	4	--	--	40	100
"	6	--	--	80	80
Tordon	¼	40	80	--	--
"	½	60	100	80	20
"	1	100	100	100	100
"	2	100	--	100	100
Tordon Mixture	1	--	--	80	40
"	2	--	--	100	100
"	4	--	--	100	100
6-inch spacing					
2,4,5-T	1	0	60	--	--
"	2	0	--	20	20
"	4	--	--	20	40
"	8	--	--	0	100
Tordon	¼	20	40	--	--
"	½	80	100	100	20
"	1	100	100	100	0
"	2	60	--	100	60
Tordon Mixture	2	--	--	100	80
"	4	--	--	100	60
"	8	--	--	100	100

1/ Trees showing 60 percent or more top kill by August 1964.
2/ Triethylamine salt of 2,4,5-T diluted with water to 2 lb. a.e. gal.
3/ Tordon (4-amino-3,5,6-trichloropicolinic acid) as the potassium salt, 2 lbs. a.e./gal.
4/ Mixture of Tordon at 0.54 a.e./gal. and 2,4-D at 2 lbs. a.e./gal. as the triisopropanolamine salt.

Other species showing evidence of being controlled by Tordon treatments that are effective on red oak up to about 12 inches at d.b.h. include elm, eastern hophornbeam, black cherry, boxelder, and red cedar (probably most conifers). For any species, all small size trees up to about 8 inches d.b.h. and suppressed trees regardless of diameter were killed with 1 ml. injections of Tordon 101 Mixture spaced 2 inches apart. These included small white ash, hickory, red maple, sugar maple, and beech in well-stocked stands. Large, dominant-crown-class trees of these same species, however, showed no effects. Therefore crown size may be more important than species or tree diameter.

Trees growing in sprout clumps are often more resistant than single stemmed trees of the same size. We also find that more effective tree kill is obtained by applying the herbicide injections to the stems above basal burls and fire scars. All of these considerations need to be kept in mind for effective control work with chemical tree injectors.

Translocation.--The stage of growth or season of the year when basal injections are made appears to be less important with Tordon than with 2,4,5-T except perhaps on sugar maple. This species showed no effects of Tordon injections during the sap flow season (6) whereas our summer treatments with Tordon 101 Mixture showed some top-killing effects within one month.

Herbicides differ in their manner of translocation. Leonard (3) reports that Tordon and Amitrole move in both the living and non-living parts of the plant. In contrast, the acid and salt forms of 2,4-D and 2,4,5-T are translocated primarily in the living parts of plants.

In basal injections, various forms of 2,4-D and 2,4,5-T and Tordon are caught in the transpiration stream of water and are carried upward to the top of the tree. In this upward movement we have observed that some of the 2,4,5-T and Tordon moves to the cambium and adjacent bark, causing abnormal growth ruptures or tissue proliferation. The herbicide also moves out in the lower branches and kills the foliage in its upward translocation. After reaching the top of the tree, the downward movement depends on the herbicide and how quickly the leaves are killed. A quick kill of the foliage results in poor translocation downward. Leonard (3) reports that the water soluble amines of 2,4-D and 2,4,5-T are moved downward more effectively than the esters and that the oil soluble esters need to be hydrolized before appreciable movement takes place in plants. He also found that the downward translocation of Tordon is superior to that of 2,4-D and 2,4,5-T.

Other investigators (6) report that only one side of the tree crown was killed when half of the basal portion of the tree was treated with Tordon in basal cut surface applications. Tordon as well as other herbicides appear to fan out in their upward movement to kill the crown above the injections.

Downward translocation to the root system from trees treated by basal injection applications of Tordon at the rates we used has not affected the other trees in the same sprout clump or adjacent trees by root grafts. Many of our Tordon injection treatments were applied to only one of the trees in a sprout clump or to only the poorest quality ones. To date, none

of the untreated trees in these sprout clumps have been affected by the single-stem treatments. It may be possible with tree injectors to apply Tordon low enough around the base of sprout clumps to kill more than one stem, but we did not try it.

Suggested Herbicide Prescription Guides for Tree Injectors

For tree injectors herbicide prescription guides suggested from our results and those of other investigators to control red oak and similar resistant species with Tordon and with the amine salts of 2,4-D and 2,4,5-T are summarized in Table 3 for the benefit of practicing foresters and land managers.

Table 3. General herbicide prescription guides for tree injectors for trees up to about 12 inches in diameter. 1/

Spacing Interval of the Injections (edge to edge)	Tordon 22K	Tordon 101	Amine salt 2,4-D or 2,4,5-T diluted with water to 2-lb. a. e. gal.	
	All Seasons	All Seasons	Peak of Growing Season	Other Stages of Growth
	- - - - -	(volumes per	injection	mls.)- - - -
2 inches	1/4	1	1	4
4 inches	3/4	1-1/2	4	-- 2/
6 inches	1	2	8	-- 3/

1/ Large dominant and codominant maple, beech, hickory, and white ash are more difficult to control. For these species and trees over 12 inches in diameter, suggest overlapping tree injector cuts with 2,4-D amine or double the Tordon volumes and keep injections spaced at 2-inch intervals.

2/ Inadequate data.

3/ Not recommended.

Many factors affect the tree kill obtained from tree injector treatments. Major points to remember are:

1. The total volume of herbicide applied per tree at constant volumes per injection will depend on the width of the cutting head of the injector, the spacing interval and the basal diameter and corresponding circumference of the tree. Increasing the spacing interval from 2 to 6 inches decreases the number of injections per tree by one-half.

2. The total volume of a particular herbicide required to kill a tree should normally depend on the size of the tree as well as species. Crown size may be more important than the diameter of the main stem or even species. With tree injectors the total volume of herbicide

applied per tree increases in direct proportion with the tree diameter -- doubling the tree diameter doubles the herbicide volume. However, herbicide volumes per tree may increase with the square of basal stem diameters, and herbicide volumes per injection may have to be doubled as the basal diameter doubles.

3. The water soluble amines of 2,4-D and 2,4,5-T translocate more readily in woody plants than the oil soluble esters (3). Therefore the amines are generally more effective in basal injections than the esters.

4. Amine salts of 2,4-D have been found to be about as effective in basal injections as those of 2,4,5-T on many species including oaks (4, 5), and sugar maple (2), but somewhat less effective on red maple (1). Since 2,4-D costs only about one-third as much as 2,4,5-T and is nearly as effective, it has certain cost advantages in tree injector operations. Amine salts of 2,4-D at 4 lbs. a.e. gallon are usually thick, sirupy-like liquids. At cool temperatures they are difficult to apply with tree injectors unless diluted with water.

5. Tordon has superior translocation properties in woody plants over 2,4-D and 2,4,5-T herbicides. It is more effective on difficult-to-kill species and can be used at smaller volumes and at wider spacing of the injections in year around operations.

6. Tordon 101 Mixture is also more effective than the amine salt of 2,4-D and 2,4,5-T and can be used in smaller volumes and at wider spacings of the injections in year-around operations. This herbicide, like the amine salts of 2,4-D, is a thick, sirupy-like liquid and is difficult to apply at cool temperatures with most tree injectors unless diluted with water.

7. Tordon may be applied with tree injectors at any convenient height on the basal portion of the tree for equally effective results. Placing the injections above fire scars, burls, and other basal defects appears to be more effective than placing the injections directly into the callus growth caused by these defects.

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PRE-COMMERCIAL THINNING OF PINE WITH HERBICIDES AND SOIL STERILENTS[1]

by

William P. MacConnell[2] and Richard G. Babeu[3]

An important phase of forest management in the Northeast is controlling the spacing of trees in stands of Eastern white pine to attain rapid growth and quality. Research in the use of herbicides to control forest composition and density has generally been directed toward solution of the more urgent cull hardwood problem rather than control of conifers in thinning operations. Most thinning operations in coniferous stands have been accomplished through cutting, and in older stands the material removed has often been sold to defray part or all the cost of the operation. Many pine stands urgently in need of thinning are too young to produce saleable material, and older stands become more subject to Fomes annosus root rot after cutting.

The F. annosus root rot problem is so severe that it is considered responsible for ninety percent of the decay in conifers in Great Britain.[1] Fomes annosus infections are frequently the result of thinning or other felling operations.[1,4,5] This fact is supported by the frequent observation that F. annosus damage is not common in unthinned white pine stands, but is frequent in thinned stands. Over fifty percent of the trees in natural or planted stands can be infected and infection of standing trees is clearly related to neighboring stumps.[4]

Control of F. annosus is achieved by stump treatment with creosote, urea, or borax. This material should be liberally applied by means of a brush immediately after felling to prevent entry by the F. annosus spores[1] which are discharged continuously throughout the year.[4]

Dead standing trees and stumps made when dead trees are cut are not as susceptible to F. annosus as stumps produced by cutting live trees. Red pine and loblolly pine killed quickly by sodium arsenite poison or by suppression have not become infected by the fungus. Trees killed slowly by 2-4-5-T, on the other hand, are liberally infected and the fungus fruited at the site of herbicide application.[2] This information suggests that trees quickly killed by herbicide in thinning operations would be less susceptible to F. annosus than those felled.

Four commercial formulations of herbicide were used to thin natural white pine stands. Fenuron (3 phenyl-1, 1 dimethylurea) was used as a soil steri-

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lent, and three fast acting herbicides were applied in connected hacks by tree injector. The three herbicides were all diluted 1 to 1 in water while the fenuron at 25% strength in inert clay was in pellet form. The commercial herbicides used were the amine form of 2,4-D (Dimethylamine salt of 2,4-D), the amine form of 2,4,5-T (Triethylamine salt of 2,4,5-T) and Tordon (4 amino-3,5,6 trichloropicolinic acid with 2,4-D). All the materials successfully killed pine and no F. annosus has yet developed.

THE FENURON TEST

The stand selected for thinning by soil sterilent was extremely dense so that the hazard of killing reserve trees would be great and a rigorous test of the method would result. Trees in the natural pine stand averaged 24 years of age, 26 feet in height, and 4.3" dbh. Diameters ranged from 1" to 10" dbh and two trees 24" dbh were treated. There were 1075 living trees per acre with 117 square feet of basal area. The average spacing between trees was 6.4', but most of the trees treated were in dense clumps 1' to 5' apart. The soil was coarse sand and the litter was 3 inches deep.

The method of treatment used in early August 1962 was application of 1 tablespoonful of fenuron pellets for each 4" of tree diameter. The duff was scraped back with the heel in a small patch 1' from the tree stem, and 1 tablespoonful of fenuron pellets was placed in a pile on the mineral soil and was covered by litter. This application was evenly spaced around the tree stem at the rate of 1 tablespoonful for trees 4.0" dbh and under, 2 tablespoonsful for 4.1" to 8.0" dbh, etc. Where possible, applications were made on the side of the treated tree away from the nearest reserved tree. Paint stripes for each tablespoonful of fenuron applied were marked above the point of application on the 178 treated trees.

Fenuron has a very low toxicity rate. In a recent study on Bobwhite Quail[3] birds were fed as much as 2,309 milligrams of fenuron per killogram of body weight without adverse effect. The only observable reaction was that the birds fed fenuron did get fat--hopefully not so fat that they cannot fly, else users of herbicide are again in trouble.

Results of the treatment applied in August 1962 were observed in mid-September 1962 without locating any damaged trees. Trees began to show damage in February 1963. In August 1963, one complete year after treatment, the condition of each treated tree was evaluated and recorded. In August 1964 the condition of each treated tree was again observed and two more treated trees were dead (Table 1) while none had recovered. The material when applied this way was effective in killing or severely damaging 90% of the treated trees after one growing season and conditions were little changed after two growing seasons. One of the open grown treated 24" dbh pines was dead; the other had lower branches still living.

Unfortunately 57 untreated trees were dead by August 1963 and 82 were dead by August 1964, while the remaining trees showed no damage. The position of dead trees was analyzed to determine if more trees were accidentally killed

when the fenuron was applied on the side of the treated tree nearest the tree accidentally killed. Nearly one-half of the trees accidentally killed were on the side opposite the treatment spot on the nearest treated tree; so fenuron application on the side of a treated tree away from the nearest reserved tree does not substantially reduce accidental mortality.

Table 1. Condition of 178 White Pine Trees Two Years After Treatment with Fenuron in Pelham, Mass.

Tree Condition	Tree diameter in inches											Total No. of Trees	% of Total
	1	2	3	4	5	6	7	8	9	10	24		
Dead	0	8	48	31	24	13	9	3	0	1	1	138	78
50% + injured	0	0	3	2	5	5	2	5	1	1	1	25	14
Alive	0	0	0	0	3	2	3	4	2	1	0	15	8
Total	0	8	51	33	32	20	14	12	3	3	2	178	100

Table 2. Number of White Pine Trees Accidentally Killed Two Years After Treatment with Fenuron in Pelham, Mass.

DBH	Distance from the nearest treated tree in ft					Total Number	% of Total
	1	2	3	4	5		
1	0	0	0	0	0	0	0%
2	4	9	2	2	0	17	21%
3	4	9	13	1	1	28	34%
4	6	6	10	2	0	24	29%
5	1	5	1	2	1	10	12%
6	1	0	0	1	1	3	4%
Total Number	16	29	26	8	3	82	100%
% of Total	19%	35%	32%	10%	4		100%

The distance of trees accidentally killed from the nearest treated tree was next analyzed (Table 2). Too many trees were accidentally killed, but none were killed at a greater distance than 5' from a treated tree, and 84%

of them were within three feet of a treated tree. The 82 trees accidentally killed amount to 4.1% of the stems in the stands treated. This technique of thinning pine deserves more study especially in stands with wider spacing.

TREE INJECTOR TESTS WITH 2,4-D, 2,4,5-T AND TORDON

The stand selected for thinning with the three fast-acting herbicides was densely stocked so that hazard of backlash would be high. All hardwoods had been removed from the pine stand ten years previously, the crowns had closed, and the stand needed thinning. Trees in the stand averaged 41 years of age, 46 feet in height, and 6.4" dbh. Diameters ranged from 4 to 14" dbh and most of the trees were less than 8" dbh. The stand averaged 747 living trees per acre with 167 square feet of basal area. The average spacing between trees was 7.4', but most of the trees treated were in dense clumps. The soil was sandy loam and the litter was 4" deep.

The method of treatment employed in early May 1964 was application of the amine form of 2,4,5-T, Tordon and the amine form of 2,4-D all mixed at 1 to 1 in water. One milliliter of each herbicide mixture was applied in connected hacks by a tree injector with a 3" curved cutting edge.[1] The amine form of 2,4,5-T was used to treat 280 trees totaling 1411 diameter inches (D.I.). Tordon was used on 212 trees with 1085 D.I.; the amine form of 2,4-D was used on 64 trees with 357 D.I. and 65 trees with 369 D.I. were felled by chain saw. The trees removed by chain saw were cut off with a single diagonal cut at breast height to reduce the work involved. One-half of these trees were also cut at the usual stump height to determine if there is a difference in F. annosus infection between the two stump heights. No control measures for F. annosus were employed and a forest pathologist has agreed to carefully watch the stand for the next four years.

Results of the treatments applied in May 1964 were evaluated in November of that same year. Treated trees had either completely died or showed little damage at the end of the first growing season. Trees completely browned out were tallied as dead. All others were considered alive. The amine form of 2,4,5-T killed 84% of the treated trees, 2,4-D in the same form killed 91%, and Tordon 94%. All of the herbicides were less effective on trees over 8" dbh because of the thickness of the bark at the base of the tree. Tordon was most effective, 2,4-D next, and 2,4,5-T was the least effective herbicide used. All the materials effectively killed trees in one growing season and should provide better protection against infection by F. annosus than would felling trees. Two trees were killed by lashback. On the Tordon plot the 6" dbh victim had three treated trees all within four feet of it. The other, a 7" dbh tree on the 2,4-D plot, had three treated trees within three feet of it. Lashback appears to be an unimportant problem with the herbicides used when applied by tree injector.

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[1] Cran-jector manufactured by Cranco Company, Trenton, N. J.

COST

Costs are nearly three times as great with the soil sterilent method (Table 3). This method was not only most costly, but was also most hazardous to the residual stand. The other four methods were about equal in cost for treatment of 1000 diameter inches of trees at breast height, but the cost to kill 1000 D.I. was more variable. Cutting with the chain saw proved most economical in this test. However, it should be understood that the amount of work accomplished varies greatly with the chain saw operator while tree treatment by injector is more uniform among different workers.

Table 3. Labor and Materials Required to Treat and to Kill 1000 Diameter Inches of White Pine in Thinning Operations by Various Methods (In Dollars)

Method	Cost per 1000 diameter inches					
	Man Hours	Labor Cost	Material Cost	Equipment Cost	Total Cost To Treat	Total Cost To Kill
Fenuron Soil Sterilent	3.27	$4.90[1]	$13.77[6]	----	$18.67	$20.16
Amine form of 2,4,5-T	3.86	5.79[1]	.95[4]	.20[3]	6.94	8.05
Tordon	3.86	5.79[1]	.95[4]	.20[3]	6.94	7.36
Amine form of 2,4-D	3.86	5.79[1]	.34[5]	.20[3]	6.33	6.90
Felled by chain saw	2.71	5.42[2]	----	1.35[7]	6.77	6.77

1. Labor at $1.50 per hour.
2. Chain saw operator @ $2.00 per hour.
3. Injector at $.05 per hour depreciation.
4. 2,4,5-T and Tordon @ $9.00 per gallon cost.
5. 2,4-D at $3.40 per gallon cost.
6. Fenuron "Dybar" at $1.62 per pound in 10 pound lots.
7. Chain saw with fuel, etc. at $4.00 per day rental.

CONCLUSIONS

The five methods studied are all suitable techniques for thinning white pine. Cutting by chain saw is most economical, but offers most risk of incurring infection of the stand with F. annosus. Fenuron soil sterilent is several times more expensive and offers most risk of killing reserve trees, but it requires no special equipment and the work is easy; so the technique deserves further study.

The amine form of 2,4-D performed exceptionally well and was next in economy to the chain saw. Tordon was next in cost for diameter inches killed and the amine form of 2,4,5-T was last. All the herbicides tested in the tree injector killed trees quickly and all may be recommended with confidence for thinning pine.

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Chemi-thinning with 4-amino, 3,5,6-Trichloropicolinic Acid and Dicamba

Robert R. Morrow[1]

Chemi-thinning of forest trees with 2,4-D and 2,4,5-T compounds is a well-established practice. In northern hardwoods it is necessary to make a complete frill to obtain successful results with most species (2,3,4). Recently, however, Leonard (1) has found that two newly-developed compounds, Tordon and dicamba[2], are more easily translocated in woody plants. This suggests that these chemicals, placed in spaced cuts, may kill trees with a considerable reduction in labor costs. Tests were made in 1963 and 1964 on many forest trees in southern New York; preliminary results are reported here.

The preliminary series of tests, except as noted, were made by squirting undiluted chemical into waist-high axe cuts spaced one inch apart. About a dozen healthy trees, usually 5-12 inches in diameter and including sugar maple, red maple, beech, white ash, and basswood, were used for each treatment. The Tordon had 1.4 pounds active ingredient per gallon; dicamba had 4 pounds per gallon. Table 1 gives other data for the tests.

Table 1. Specifications of preliminary tests.

Application date, Temperature	Treatment number	Chemical	Concentration	Milliliters per cut	Milliliters per diam.-inch.
8-16-63	1	Tordon	undiluted	1-2	1
70°F.	2	Tordon	diluted 1-70	1-2	1
	3	Tordon(frill)	diluted 1-70		3-4
	4	Dicamba	undiluted	1-2	1
12- 6-63	5	Tordon	undiluted	<1	0-1
40°F.	6	Tordon	diluted 1-3	1-2	1
	7	Dicamba	undiluted	1-2	1
3-17-64	8	Tordon	undiluted	1-2	1
40°F.					
5-20-64	9	Tordon	undiluted	1	<1
60°F.	10	Dicamba	undiluted	1-2	1

Preliminary results of these tests are as follows (June 16, July 27, Sept. 15 ratings):

1. Undiluted Tordon caused 75 percent or more top-kill of all species for all treatment dates, except (a) no kill of maple from March treatment when sap was running profusely and (b) slightly less than 75 percent top-kill for sugar maple from December treatment

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[2]Tordon is the trade name for 4-amino-3,5,6-trichloropicolinic acid and dicamba is 2-methoxy-3,6-dichlorobenzoic acid. They were, respectively, supplied for testing purposes by The Dow Chemical Co. and Velsicol Chemical Corp.

when there was a weak sap flow. Watson and Mesler (5) also reported poor results associated with April sap flow.

2. Undiluted dicamba caused generally good top-kills, with the exception of sugar maple which appeared to be generally resistant.
3. Diluted Tordon (25% in water) in cuts was ineffective except for basswood. Diluted Tordon (1.5% in water) in complete frills is slow-acting, but probably will eventually kill all the trees.
4. Partial refoliation (about 25 percent) in midsummer following earlier complete defoliation was observed on white ash (treatments 1 and 5) and sugar and red maple (treatment 4). Maple leaves were deformed, while ash leaves were smaller than normal.

Since results of these preliminary tests showed considerable promise, a series of larger and more refined tests were made during the fourth week of June 1964. Tree diameters were measured, cuts were carefully spaced, and small amounts of undiluted Tordon and dicamba were metered into the wounds. Cuts were made at a height of three feet with sufficient force to pass through the cambium; average width of cut was just under three and one-half inches. Treatments included one-quarter and one-half milliliter per cut, spaced one and three-quarters inches apart, for each chemical; also one-half and one milliliter per cut, spaced three and one-half inches apart, for each chemical. Each treatment was made on 20-25 healthy trees on average or better forest sites. Altogether 175 trees, most between 5 and 17 inches in diameter were used; they were predominantly sugar maple, red maple, beech, basswood, white ash, and yellow birch.

On September 15, less than three months after treatment, the principal results were as follows:

1. Most basswoods were completely defoliated by all Tordon treatments.
2. Sugar maple was 50 percent defoliated by all Tordon treatments, except where only one-quarter milliliter per cut was applied.
3. Other species were not consistently affected, and beech and white ash appeared relatively unaffected. Red maple and yellow birch were defoliated 50 percent by only the one milliliter treatment.
4. Best Tordon treatment was the one milliliter application in widely spaced cuts. When coupled with the poor results following dilution of Tordon in the August and December treatments, this suggests that minimum dosage may be a critical factor. On the other hand, translocation of Tordon is apparently sufficient so that quite wide spacing between cuts may be possible.
5. Dicamba caused little defoliation of any species; basswood was most seriously affected.

These results must be regarded as preliminary and tentative, not only because sufficient time has not elapsed for final evaluation, but because the effect on the experiment of the rather severe droughts of the past three years is unknown, However, they may be helpful in guiding further experimentation.

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Northern Hardwoods Need Complete Frill

Robert R. Morrow[1]

Most of the northern hardwoods require a complete frill to insure deadening with 2,4-D and 2,4,5-T compounds applied in the dormant season (1,2,3). A recent test shows that some northern hardwoods also require a complete frill with growing season applications.

In early June, 1963, undiluted 2,4,5-T amine was applied in axe cuts to 37 trees on an average growing site in southern New York. Approximately one inch of live wood was left between each cut; one milliliter[2] of chemical was added to each cut. Table 1 shows the amount of top-kill after nearly two growing seasons.

Table 1. Top-kill on July 29, 1964

Species	No. trees	Avg. D.b.h.	Avg. no. cuts	Top-kill rating[3]
Red maple	4	6"	6	2-4
Red maple	2	9"	8	1
Sugar maple	4	6"	7	3
Sugar maple	3	11"	9	1
Beech	5	6"	6	2-3
Beech	5	12"	10	1
White ash	5	9"	7	2-3
Basswood	1	6"	5	1
Yellow birch	3	7"	7	3-4
Black birch	2	7"	7	3
Miscellaneous	3	7"	7	3-4

Good top-kill was generally obtained on birch and on small stems. Most northern hardwoods larger than eight inches in diameter still retained over half of their live crowns, and from past experience, most will at least partially recover and continue to compete with their neighbors. These results support those of Little and Fenton (1) for similar species in northern New Jersey and suggest that complete frills are needed in any season for a high degree of success with many northern hardwoods.

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[1]Assoc. Prof. of Forestry, Dept. of Conservation, Cornell University.

[2]A commonly and commercially recommended treatment.

[3]Rating from 0(no kill) to 4(complete top-kill).

HERBICIDAL TREATMENT OF WATERSHEDS TO INCREASE WATER YIELD

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MANY STUDIES have shown that water yields from forested watersheds may be increased by cutting the trees (Hewlett and Hibbert, 1961); Reinhart et al., 1963). The experiment under discussion aims to determine, for the specific study area and conditions during the experiment, the maximum increase that can be obtained by manipulation of vegetation. This means the complete elimination of vegetation, or as near to that goal as we can come. An added objective is to test the effect on water yield of vegetation removal in different parts of a watershed; therefore the watersheds are being treated by steps. We divided each watershed into halves, designated Upper and Lower, with the boundary between the two on the contour.

THE STUDY WATERSHEDS

Two gaged watersheds, Numbers 6 and 7 on the Fernow Experimental Forest near Parsons, West Virginia, were selected for treatment in this experiment. Watershed 6 is 55 acres in area, No. 7 is 60 acres. Their streamflow had been calibrated against the flow of another nearby watershed, the control, over a period of 7 years.

The virgin forest in this area was cut between 1905 and 1910. The second-growth stand before treatment was composed largely of the oaks (red, chestnut, and white), red and sugar maple, and yellow-poplar. The following tabulation gives data on a per-acre basis of the stand over 5 in. diam breast high (dbh) for Lower 6 and Upper 7, the areas currently being treated:

Watershed	Area (acres)	Stems (No.)	Summation of dbh-inches (No.)	Volume (bd ft)	Basal area (sq ft)
Lower 6	27.6	180	1,774	14,300	116
Upper 7	29.9	141	1,517	16,000	112
Combined area	57.5	160	1,640	15,200	114

There was of course some additional vegetation of smaller size: for example, about 375 stems and 580 dbh-inches per acre in the 1- to 4-inch dbh classes. The measure of total dbh-inches is probably more useful than volume or basal area when stems are treated individually.

VEGETATION REMOVAL

The basic plan for watershed treatment was fairly simple:

1. Dormant-season harvest of all sawlogs by Experimental Forest crews.

2. Dormant-season harvest of pulpwood and charcoal wood by purchaser of stumpage.

3. Felling of any remaining trees over 20 ft in ht by Experimental Forest crew.

4. Dormant-season treatment of stumps with herbicide to control sprouting.

5. Growing-season foliage spray, using mistblower early in season.

Actually the logging job was accomplished much more slowly than planned, and many changes in schedule were made.

All herbicide so far used in this study has been the iso-octyl ester of 2,4,5-trichlorophenoxyacetic acid, hereafter referred to as 2,4,5-T. As purchased, its concentration was 6 lb aeg.

Basal spray.--All trees above 1 in. dbh were basal-sprayed in October or November 1963, using 2,4,5-T (16 lb aehg) in No. 2 diesel oil. Garden sprayers of about 3½-gal capacity were used. Leaves were raked away from the base of the tree after which the lower stem (up to a height of about 1 ft) was sprayed until the liquid could be seen running down onto the root collar.

This treatment was made before the logging operation for two main reasons: the availability of labor, and the greater ease in covering the ground without interference from slash.

The following tabulation gives materials and labor for the combined area, 57.5 acres of Lower 6 and Upper 7:

Item used	Quantity	
	Per acre	Per dbh-inch
2,4,5-T, gal	0.48	0.0002
Diesel oil, gal	18.33	.0073
Labor, man-days	1.50	.0006

Logging.--Logging operations for both sawlogs and pulpwood were started in Upper 7 in November 1963 and completed at the end of May 1964. Operations in Lower 6 extended from March to October 1964.

After the trees were cut, 2,4,5-T (the same mix as used for basal spray) was sprayed onto the sapwood. This job was small compared to the basal spraying. Volumes applied per acre were 0.1 gal of 2,4,5-T in 2.9 gal of diesel oil, requiring 0.2 man-days of labor.

After completion of the harvesting operation, all trees remaining that were over 20 ft in ht were felled. Many of these may have died eventually as a result of the basal spray, but we wanted a quick and thorough kill. This required about 0.5 man-days per acre. After this operation, there was nothing left that could not be easily reached by mistblower in case of loafing out.

Foliage spray.--So far, only Upper 7 has been treated with a foliage spray. This treatment for Lower 6 will be postponed until the spring of 1965 because of delay in completing the logging operation.

On Upper 7, a backpack mistblower was used with 6.6 gal of 2,4,5-T (6 lb aeg), 20 gal of No. 2 diesel oil and 73.4 gal of water per 100 gal of mixture. The area was covered in the period from May 19 to June 11, 1964; then a touch-up job was done in the period from August 7 to September 8, 1964. The following data apply to the 30 acres of Upper 7 only:

Mistblowing period	Application in gpa			Labor in man-days/acre
	2,4,5-T	Diesel oil	Spray mixture	
May-June	0.80	2.43	12.1	0.7
Aug.-Sep.	.36	1.13	5.7	.3
Sum	1.16	3.56	17.8	1.0

TREATMENT EFFECTS

On Vegetation.--The results have been good, although it goes without saying that we completely eliminated neither vegetation nor transpiration.

Stump sprouting was virtually eliminated. Some root sprouts did develop, especially black locust. These were later killed, for the most part, by the foliage spray.

Table 1 gives results of vegetation surveys before and after treatment of Upper 7. In the method used, the percentage of ground cover by each class is estimated, assuming vertical projection; thus it is possible to arrive at totals far above 100%. After treatment, the only class with any appreciable density was the forbs (broad-leaved herbaceous plants); the most numerous were pilewort (*Erechtites* sp), pokeweed (*Phytolacca* sp), and violet (*Viola* sp). Of the tree seedlings, white ash (*Fraxinus americana*) appeared to be most resistant.

There were 30 post-treatment plots in the vegetation survey; on every 6th plot the foliage was clipped, oven-dried, and weighed. Foliage weight averaged 65 lb per acre. We did not measure foliage weight before treatment, but some idea can be obtained from studies of leaf fall. Hart et al. (1962) reported an average leaf fall of 2,820 lb, oven-dry weight, per acre in a northern hardwood forest in New Hampshire. Accepting this figure as a pre-treatment estimate indicates that treatment (both cutting and spraying) eliminated about 98% of the foliage.

Table 1.--Average ground cover in percent, by various classes of vegetation before and after treatment in Upper 7

Period	Woody stems*				Herbaceous		Total
	I	II	III	IV	Forbs	Grasses	
Before	82	43	19	6	37	1	188
After**	0	0	1	T	16	2	19

*The four classes are: I. 5-in. dbh and over; II. 1- to 5-in. dbh; III. over 1 ft in ht but less than 1-in. dbh; IV. under 1 ft in ht.

**Survey made September 10-11, 1964.

On water quality.--During the spraying operations, numerous water-quality samples were obtained from the stream immediately below the treatment area. Each of these samples was sniff-tested by a panel of at least 3 persons. No odor could be detected, even though panel members demonstrated their ability to pick out specially prepared samples containing only 0.5 ppmv of spray mixture. We realize that this test may have more to do with the presence of No. 2 diesel oil than 2,4,5-T; however, the fact remains that no odor effect on the water was detected.

On water yield.--It is still too soon to say much about the effect of treatment on water yield. It is apparent that some increase is occurring on both watersheds. Preliminary analysis indicates that on Watershed 7, in the 6-month period from May through October 1964, the increase was slightly over 7 area-inches of water on the treated area. This amounts to almost 200,000 gal of additional yield from each acre treated. In the month of August alone, yield was increased by an estimated 45,000 gal from each treated acre. Time will tell whether or not increased yields of this magnitude can be maintained over the next few seasons.

FUTURE TREATMENT

A good start has been made, but only part of the job has been done. Herbicides must be applied to keep the vegetation at a minimum for the next 2 growing seasons on the areas already treated. Then we plan to treat the remaining 2 half-watersheds in much the same manner. It is apparent that next spring we must use some other herbicide instead of or in addition to 2,4,5-T in order to control grasses and some of the more resistant herbs.

DISCUSSION AND SUMMARY

I want to emphasize that this is a watershed-research project, not a study of methods for killing vegetation. Further, the study is not meant to demonstrate a practical method of increasing water yield.

The measures employed have pretty well attained the objective of near-elimination of vegetation. They can probably be improved considerably, and we will try to do so.

Costs (in terms of labor and materials) have been given only to describe the research project. They are not recommended for use in practical application.

Several operations have been discussed separately. Per-acre applications for the several jobs (basal spray, stump treatment, felling residuals after logging, and mistblowing) add up to: 1.8 gal of 2,4,5-T, 25 gal of diesel oil, and 3.2 man-days of labor. Labor used in harvesting sawlogs and pulpwood is not included.

In spite of heavy applications of a phenoxy herbicide, water quality was not affected. Similar results were obtained by Reigner et al. (1964) in New Jersey and Pennsylvania.

Treatment increased water yield from the treated area of Watershed 7 by almost 200 thousand gal per A in the May-October period of 1964; to properly evaluate the treatment we will have to wait until yields have been measured over a longer time period.

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PREPARATION OF HARDWOOD HARVEST CUTTINGS FOR REGENERATION BY AERIAL SPRAYING

Paul W. Sundheimer [1]

INTRODUCTION

The Allegheny National Forest consists of 470,000 acres of which 450,000 acres is commercial forest land organized for the production of timber crops. The timber resource now occupying this acreage is primarily a black cherry-maple complex. Oak and coniferous types cover about 15% of the area. All types generally occur in even-aged (but uneven size) stands from 2 to 100 acres in size.

The present long range management objective is to produce a forest composed of 50% black cherry by volume; 5% coniferous species and 45% red maple, sugar maple, red oak, birch, white oak, white ash and beech. Most of these species are light demanding for regeneration and growth to maturity. This requirement makes an even-aged system of management necessary to achieve the desired objectives.

The methods of cutting now practiced consist of making a series of thinnings, beginning between the 20th and 40th year with a pre-commercial treatment, then continuing with commercial thinnings at ten year intervals until a rotation age of 100 years old is reached when regeneration cuttings are made. Such cuttings are also made in immature stands (1) to provide a brush stage in the vegetative pattern desired for wildlife, (2) to liquidate stands of unacceptable quality and quantity stocking and replace with more desirable stands. Regardless of the purpose or justification for the regeneration cutting each area is treated to obtain desirable natural regeneration in the shortest time. The rate of these cuttings is governed by an allowable cut in terms of acres which will eventually yield a balanced age class structure by area for the entire Forest. Each of over 1200 compartments in the Forest will be entered every 10 years for examination and subsequent treatment. Each treatment will include regeneration cuttings to some extent. This schedule is intended to produce a forest eventually composed of a series of even-aged stands between 5 and 50 acres in size. At the present time, regeneration cuttings are being made at the rate of 1800 acres annually. This rate will gradually increase to 3100 acres per year.

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SITE PREPARATION METHODS

Each regeneration cutting area is treated first by removing all commercial timber as part of a timber sale covering one or more compartments. The remaining woody vegetation is treated with herbicides in a variety of ways to eliminate trees or shrubs which will inhibit or interfere with the natural establishment of desirable tree species from seedlings or seedling sprouts. At the present time we are not certain that all vegetation must be eliminated. There is evidence that such woody growth as beech reproduction originating from suckering is not generally a threat. There are also indications that some degree of shade may be beneficial. Experience in various methods of applying herbicides has demonstrated that a complete kill in the literal sense is seldom achieved.

The methods used to date to kill undesirable woody growth vary with the amount and stratification of such growth following the commercial cuttings. If the residual stand consists of only 20 square feet of poles, the use of injectors to apply metered doses of concentrated 2-4-5T with each stroke has proved economical and effective. Trained workers are essential for the use of this tool. The training must indeed include motivation to use the tool effectively. This may be as difficult as trying to convert a double bit axeman to the use of a single bit axe.

The use of a foliage spray applied with a powered mist blower has been effective and acceptable for cost where the terrain of the area is gentle and the woody vegetation is less than 15 feet tall and not too dense. However, movement is handicapped if the low growth is dense and the ground is covered with a heavy layer of tree tops.

Basal spray and frill treatments have also been used. An acceptable kill has been achieved but costs are not attractive.

In the spring of 1963 the first plan was designed to test the application of foliage sprays by aerial spraying. This method appeared attractive based on costs and effectiveness experienced in applying insecticides under comparable conditions. Moreover, it simplified handling materials and equipment and made possible the completion of large acreages in a comparatively short time. These features made the method attractive to managers of large work programs. The greatest disadvantage to aerial spraying was the degree of damage to be expected from drift.

AERIAL SPRAYING

The 1963 project was set up to aerial spray six regeneration cutting areas totaling 95 acres from which the commercial timber had been removed one or two years earlier. The original plan was designed with the expectation of using various herbicide mixtures in the conventional mist size droplets. Later, advice was obtained on the availability of prepared chemicals and special spraying equipment for the application of invert emulsions. The original plan was then amended to include this new facility because it would minimize drift and make for greater pilot accuracy. In the final plan, costs of aerial spraying were a secondary consideration.

The six areas treated varied from 5 to 30 acres in size and contained 10 to 30 square feet of basal area per acre in unmerchantable red maple, sugar maple and beech trees. Cut stumps from the sale operations had sprouted to a limited extent, with cherry the most prolific and vigorous. There were also patches of dense beech sprouts and vigorous striped maple five feet high. In other portions of the same areas dense stands of two and three year red maple and cherry seedlings six to twelve inches high were established. It was realized that this reproduction was vulnerable to a broadcast treatment with herbicides. How the seriousness of such a threat would be affected by the dosages proposed was not known, however. The overstory and down tree tops were expected to provide a certain degree of protection against droplets filtering to the ground level. Two areas also contained a light stocking of hemlock reproduction and poles.

Thirty acres were treated with an oil-in-water mixture of 2-4-5T at a rate which would give an application of 3 lbs. per acre acid equivalent. Thirty five acres were treated with a water-in-oil mixture of 2-4-5T at the rate of 4 lbs. acid equivalent per acre. All mixtures were prepared immediately before spraying. They were applied from a helicopter provided with conventional spraying equipment which distributed the herbicide in a mist.

A thirty acre regeneration cutting was divided into one eighteen-acre and three four-acre units. Each unit received an application of invert emulsion at the rate of 4 lbs. acid equivalent per acre. Four different chemical mixtures were used as follows, one on each of the four acre subdivisions: 2-4-5T, 2-4D, 5 parts 2-4-5T and one part 2-4D, and 5 parts 2-4D and one part 2-4-5T. Each chemical used was a commercial preparation which included oil and an emulsifier. A water softener was added to the water supply. The helicopter was equipped with a bifluid system which produced a heavy emulsion at the nozzle.

The project was composed of two logical subdivisions about eleven miles apart, each of which contained three regeneration cuttings. Two helispots were so located that flying distance was not more than five miles one way to either area. The areas were not delineated on the

ground with special marks to be visible from a helicopter in flight. The boundaries between the areas to be treated and adjacent timber were considered clear enough to a helicopter pilot for orientation, identification and deciding on the flight pattern to be used. All areas were located on or near the top of broad flat ridges typical of plateau topography. The elevation of the region varies from 1200 feet above sea level in the valley bottoms to 2100 feet on the flat ridge tops.

A Bell helicopter was used in the project equipped for mounting either a bifluid system or a conventional single fluid nozzle system. The hopper capacity on the helicopter was 50 gallons of mixture. Depending on the ratio of ingredients in the mixture, one trip covered 4 to 10 acres. The flying procedure consisted of first making a dry run over each area to locate boundaries and establish a flight pattern. Four inch to the mile maps were provided for the pilot's use. The herbicide was applied from a height of 25 to 50 feet above tree top level. All work was scheduled and completed on July 23. Ideal weather made this accomplishment possible. The date was later than desired but project arrangements could not be completed early enough to permit spraying during the season when plant growth is more active.

Another project was completed in the 1964 season to test the use of a single mixture on a total area almost six times larger than the 1963 project. Forty two areas totaling 567 acres and ranging from 2 to 60 acres in size were sprayed. These areas were widely scattered over the Forest. Eight helispots were used to provide a maximum flying distance of about eight miles one way. A variety of methods were used to mark selected areas. Some areas were marked with orange 12 inch cards. In other areas large orange paint spots on stumps and down tree tops visible from the air were used to denote boundary lines. Large patches of yellow paper placed along boundary lines were also tried.

The herbicide used in the 1964 project was an invert emulsion consisting of 2-4D and 2-4-5T. The mixture was sprayed to give an application of 2 lbs. acid equivalent per acre of each chemical. The helicopter was equipped with a bifluid system. The spraying job was planned for the period June 22 to July 2. It began on schedule but turbulent weather conditions forced an extension of the project to July 10. On most days only the early morning hours were suitable for flying. The contractor was required to furnish all materials and apply the chemicals as specified in the contract. The character of the forty two areas was similar to those treated in the 1963 season except rougher terrain was added in a few instances.

RESULTS

Only tentative conclusions can be made at this time about the effectiveness of the various chemical mixtures and methods of application. One of the 1963 areas treated with 4 lbs. of acid equivalent per acre of 2-4-5T oil-in-water mixture in a mist form showed a complete kill of about 15 square feet of unmerchantable overstory composed of red maple, cherry and beech. The hemlock present was only slightly burned. Ninety five per cent of the shrubs and tree seedlings were also killed. Some of the large trees showing complete top kill began sprouting in the summer of 1964. Some of the small seedlings killed are also sprouting. This evidence indicates the top kill might have been too rapid.

The water-in-oil mixture of 2-4-5T applied in mist form also shows good kill.

The use of invert emulsions applied with the bifluid system shows the greatest variation in results to date. The 1963 and 1964 projects show partial and complete kill in the residual overstory regardless of species. Some trees with a partial kill show a healthy residual top, especially those trees with deep crowns. Other trees have partial kill distributed through the top. This pattern of kill suggests uneven distribution of the chemicals. Low growth of beech and striped maple also show variation in kill, depending on the overstory. However, the effectiveness of the treatment may be sufficient to obtain satisfactory regeneration.

Several more seasons of growth are necessary before firm conclusions can be made on the effectiveness of invert emulsions applied with a bifluid system. The next project should include a test using a greater concentration of acid equivalent per acre. Increased dosage should increase the effectiveness of the droplets thereby overcoming to a greater extent uneven distribution of the chemicals or lack of more droplets reaching leaves.

Experience to date shows that foliage spray consisting of 2-4-5T or a mixture of 2-4-5T and 2-4D will kill all of the local tree and shrub species in the residual overstory and understory of regeneration cuttings. The technique of distributing an adequate dosage to the leaves needs to be improved.

The invert emulsions distributed by a bifluid system can be applied with great precision from a helicopter. It is possible to treat areas as small as 2 acres without damage to adjacent timber. Since the emulsion is rather heavy the spraying job can be done with winds up to 10 miles per hour provided turbulence does not render flying unsafe at tree top level.

Better ways need to be found to mark those regeneration cuttings with poorly defined boundaries because of residual trees in the area. Balloons have been discussed but they are subject to being punctured from the wind driving them into tree tops between placement and spraying.

Cost opportunities in aerial spraying are favorable compared to other methods of eliminating woody vegetation, where there is a residual overstory and understory to be killed. The cost advantage might be as much as $20.00 per acre compared to other methods of applying herbicides. If the residual stand is an overstory of only 10 to 30 square feet of basal area per acre other methods are probably cheaper. Size and distribution of areas and the number of helispots required are important factors affecting cost. Generally projects should contain not less than 500 acres for development of the best cost opportunities.

CACODYLIC ACID - A POTENTIAL ONE-SHOT SILVICIDE

Robert W. Smith[1]

Since its inception during the early fifties, single tree injection with tree injectors has been an important tool of foresters, particularly to control undesirable hardwoods. However, using present frill injection techniques, the relatively high cost of labor required to make multiple incisions has prohibited the use of this tool on many acres in need of such treatment.

With the increasing intensiveness of forest management in recent years in the United States, many foresters have been looking forward to the development of a more rapid system of single tree injection.

The first prerequisite of such a system would be the availability of a silvicide capable of moving throughout the conducting systems of woody stems when injected at one point on the stem.

With this objective in mind, tests were conducted on Marinette County and Ansul Company forest lands in Wisconsin. The primary purpose of these tests was to screen a neutral solution of 30% cacodylic acid[2] as a possible one-shot silvicide on both hardwoods and conifers.

The outstanding advantages of cacodylic acid are its relatively low order of mammalian toxicity, fast action, lack of phytotoxicity in the soil, and its ability to kill some trees on a one-shot basis.

Single Tree Injection of Hardwoods

During August, 1964 bore hole tests were conducted on quaking aspen, (*Populus tremuloides*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), and red oak (*Quercus rubra*).

Diameters at breast height (d.b.h.) ranged from 2 inches to 13 inches. Dosages of approximately 1 and 2 cc of the cacodylic acid solution per inch of d.b.h. were injected into single 1/2" diameter bore holes, 2-4 inches deep. Bore holes were positioned at waist height or at the bases of the trunks.

Three weeks after injection, it was apparent that the crowns of all treated species except red oak could be 100% crown killed and defoliated by 1 shot of cacodylic acid.

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The Ansul Company, Marinette, Wisconsin

2/ "ANSAR 160" is Ansul's trademark for a neutral (pH_7) equivalent of 30% cacodylic acid.

Effectiveness seemed to be related to crown diameter and density, with larger more dense crowns requiring higher dosages than smaller crowns.

Forked trees required 1 shot into each fork.

No trees larger than 13 inches d.b.h. were included in the tests. Consequently, it is not known whether or not more than 1 shot would be necessary for large trees of susceptible species.

A final appraisal will be made during Spring, 1965, when the effect of cacodylic acid on sprouting can be judged.

Further tests are planned to determine minimum dosages, optimum depth and location of bore holes and the best season of application.

Precommercial Thinning of Conifers

In August, 1964 tests were installed in Wisconsin to evaluate the feasibility of bore hole injection for thinning dense stands of jack pine (*Pinus banksiana*) and red pine (*Pinus resinosa*).

Average diameters (d.b.h.) of the jack pine and red pine were approximately 3 inches and 4 inches, respectively. Approximate dosages were 1cc and 2cc of cacodylic acid per inch of d.b.h. Bore holes were located at waist height or at the bases of the trunks. Three weeks after injection, 60% to 100% crown kills of both species were evident. Two months after injection all of the jack pine were 100% crown killed and the average crown kill of red pine was 92%. In addition, the needles of most of the treated trees had begun to fall.

Bore holes located near the bases of the trunks produced slightly faster results than bore holes at waist height. However, two months after injection, little difference was evident between waist height and basal injections.

There was no evidence of translocation through root grafts.

Effectiveness seemed to be related to crown density and diameter with larger more dense crowns requiring higher dosages than smaller crowns.

It is probable that forked trees will require one shot into each fork.

While it is still too early to draw definite conclusions concerning minimum dosages from the above tests, it is apparent that a dosage of about 5 cc per tree should produce excellent kills of jack pine and red pine within several weeks during growing season applications.

Movement of Cacodylic Acid in Trees

As a result of these preliminary tests, it is suspected that susceptibility to one shot of cacodylic acid may be related to the degree of spirality in the water conduits of trees.

Koslowski and Winget in 1963, reported different degrees of spirality among hardwoods and conifers injected with dyes in the Lake States[1]. In 1959, Vité and Rudinsky described five types of water conducting systems among conifers[2].

While information on the conducting systems of North American hardwoods is somewhat limited, it is believed that the majority of hardwood species have xylem elements which spiral, but that the degree of spirality varies within and among species[1].

Most of the commercially important conifers, on the other hand, have water conducting systems which exhibit a high degree of spirality.

Since cacodylic acid apparently readily moves through the water conducting systems of trees, species having water conduits that spiral approximately 360 degrees before reaching the lower crown could theoretically be 100% crown killed with 1 shot of cacodylic acid.

Species with water conduits that spiral approximately 180 degrees before reaching the lower crowns could probably be 100% crown killed with 1 deep shot or 2 shallow shots of cacodylic acid oppositely located on the trunk.

Species whose xylem elements spiral less than 180 degrees before reaching the lower crown would theoretically have to be injected at 3 or more points on the circumference of the trunks, depending on the degree of spirality and the diameter class.

The optimum height of the bore holes above the root collars for any given species will probably depend on the degree of spirality and on the effect of bore hole position on sprouting.

For the sake of simplicity, some species have been tentatively grouped into three classes of susceptibility to cacodylic acid based on empirical observations and recent research with trunk injected dyes.

It should be understood that there are several uncertainties involved in such an oversimplification. One obvious uncertainty is the assumption that caocydlic acid moves only through the vertically aligned water conduits without diffusing laterally at the point of injection or through xylem rays. Secondly, variation in spirality within species due to heredity or to the influence of age class, crown position, site quality, aspect and other site factors can be expected.

The tentative classifications in Table I are admittedly incomplete and based on limited data. However, they will assist those who are interested in conducting further evaluations of the efficacy of cacodylic acid as a one or two-shot silvicide. It is hoped that further research will permit a more complete and precise classification.

In summary, preliminary tests were conducted to determine whether or not cacodylic acid would kill some North American trees when injected into a single bore hole in the trunks. Although no final conclusions can be drawn, the following ideas emanated from the tests:

1. It is suspected that susceptibility to one shot of cacodylic acid may be related to the degree of spirality of the water conducting systems of trees.

2. Some species have been tentatively grouped into three classes of susceptibility to cacodylic acid based on their estimated degree of spirality.

3. Cacodylic acid has shown promise as a one-shot silvicide on some species but further research is needed to determine:
   (1) Additional susceptible species
   (2) Patterns of movement of cacodylic acid in trees
   (3) Effect of cacodylic acid on sprouting
   (4) Minimum dosages
   (5) Optimum size, depth and location of bore holes
   (6) Best season of application
   (7) Effect of heredity on spirality
   (8) Effect on age class, site quality, crown position, aspect and other site factors on the efficacy of cacodylic acid as a one-shot silvicide.

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Table I

Tentative classification of susceptibility of some trees to one-shot of cacodylic acid.

Class I (High Degree of Spirality)

Species believed to be susceptible to one shot of cacodylic acid:

* Paper birch	* Jack pine
* Red maple	* Red pine
* Quaking aspen	Ponderosa pine
* American beech	Lodgepole pine
* American elm	Southern pines
* American basswood	True firs
* Eastern hophornbeam	Spruces
* Monterey pine	Larches

Class II (Moderate Degree of Spirality)

**Species which may be susceptible to two shots (oppositely located) of cacodylic acid:

*** Paper birch	Ashes
Red oak	Douglas-fir
Red alder	Hemlocks
Sugar maple	

Class III (Low Degree of Spirality)

Species which will probably require several shallow bore holes or frills spaced around the trunk circumference:

White oak	Hickories

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* Actually tested

** On trees less than 8 inches d.b.h., one deep hole would be equivalent to 2 shallow holes oppositely located.

*** Some treated trees were only 80-90% crown killed with one-shot. It is suspected that due to variability within species, some paper birch trees will fall into Class II.

COST OF CHEMICAL FRILL-GIRDLING UNDER AN INTENSIVE MANAGEMENT PROGRAM IN NORTHERN HARDWOODS

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CONTROL OF unwanted trees is part of a long-term timber management study at the Bartlett Experimental Forest in Bartlett, New Hampshire. The objective of the study is to compare costs and returns of several treatments under intensive selection management in old-growth northern hardwood stands. The study area, totaling 569 acres, is divided into compartments that range in size from 35 to 65 acres. These compartments are large enough to study--on a commercial scale--the effects of different cutting intensities and cultural work on reproduction, growth, and timber quality.

One harvest cutting and one or two tree-killing cultural operations have been completed on practically the entire 569 acres since the study was initiated in 1951.

This paper presents data on the costs and effectiveness of several exploratory chemical frill-girdling treatments and one machine-girdling treatment that were done in 1956, and a more detailed account of a 375-acre chemical frill-girdling operation in 1963.

EXPLORATORY TRIALS--1956

Procedures

The exploratory treatments were not tests to find better ways to kill unwanted trees but merely trials of two basic methods--machine girdling and chemical frill-girdling--that had worked elsewhere and looked promising for use in northern hardwoods. The purpose of the trials was to obtain some information on costs in mountainous terrain, and on comparative treatment effectiveness and convenience of application. The treatments were:

1. Machine girdling--gasoline powered, back-mounted girdler.[1]

2. Complete chemical frill-girdling (continuous knee-high overlapping ax cuts).

   a. 2,4,5-T[2] in oil--8 lbs aehg.[3]

   b. 2,4,D[2] --2,4,5-T commercial "brushkiller" mixture in oil--12 lbs aehg, single application.

   c. Same as (b) except used in a double application.

   d. Sodium arsenite--40 percent solution with animal repellent.[4]

3. Partial chemical frill-girdling (about 1-inch spacing between ax cuts).

   a. 2,4,5-T in oil--8 lbs aehg.

   b. Sodium arsenite--40 percent solution with animal repellent.

All treatments were made during July and August of 1956 with the help of four forestry students. About one-fourth to one-half of the merchantable volume had been harvested from the areas a few years earlier. The treated trees were unmerchantable for sawlogs or pulpwood, or were of undesirable species. Most of them had been marked for removal but not cut in the prior harvesting operations. They ranged in size from 2 to 30 inches d.b.h.; about 10 percent of them were 20 inches d.b.h. and larger. The trees were mostly beech, yellow birch, red maple, and sugar maple. Minor species included hemlock, paper birch, white ash, striped maple, and pin cherry.

Two 2-man crews, working separately, were used. In machine girdling, one man operated the machine and the other man cleared brush around trees to be treated and chopped out seams that the machine could not gouge out readily. In chemical frill-girdling each man did the complete job of frilling and applying the herbicide. A plastic squeeze bottle was used for dispensing the herbicidal solution. The work of each crew was supervised by a research forester, who also tallied the treated trees. However, only the production time of the girdling crews was recorded for cost purposes.

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[1] A machine sold under the trade name "Little Beaver". Mention of trade names does not imply endorsement by the U.S. Department of Agriculture.

[2] 2,4-D and 2,4,5-T were low-volatile esters of 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid, respectively.

[3] Acid equivalent per 100 gallons.

[4] A commercial formulation sold under the trade name "Atlas D". Mention

Results

The acreage, basal area, and labor requirements of the exploratory treatments are summarized in table 1. For comparative purposes, labor expended per square foot of basal area is a convenient indicator of relative cost. As expected, the two partial frills required the least labor--0.15 and 0.21 man-hours per square foot. The other treatments ranged from 0.24 man-hours per square foot for machine girdling to 0.31 man-hours for the sodium arsenite in complete frills. The table shows a slightly higher labor cost for the single application than for the double application of the 2,4-D--2,4,5-T mixture (0.28 versus 0.23 man-hours per square foot). Differences in crew efficiency and in the character of the two areas accounted for this apparent inconsistency. For practical purposes, differences in labor requirements among the various treatments were considered to be of little significance.

The 2-year effectiveness is summarized in table 2. Sodium arsenite in complete frillsresulted in practically 100-percent kill within 2 years. In fact, high mortality was observed within 1 month after treatment. Sodium arsenite in partial frills was not quite as effective, especially on larger sawtimber trees, but was better than the other treatments.

The single application of the 2,4-D--2,4,5-T mixture in complete frills was as effective as the double application. About 82 percent of the trees were killed, and the remaining 18 percent showed crown damage in both treatments.

With complete frills, 2,4,5-T was somewhat less effective than expected. Only 62 percent of the trees were killed. A combination of relatively weak chemical mixture and poor frilling in the larger trees may have accounted for the low kill. The partial frill with 2,4,5-T was the least effective of all treatments.

Machine girdling was considerably less effective than chemical frill-girdling (except the partial frill with 2,4,5-T). Only 51 percent of the trees were killed.

Red maple was the most resistant species, followed by sugar maple and yellow birch. Older trees of these three species develop rough, fissured bark; consequently, extra care had to be taken to make deep cuts to assure effective results.

As a rule, trees up to 10 inches d.b.h. were readily killed by all treatments; but those 12 inches d.b.h. and larger were considerably more resistant--even when a thorough job was done. Trees 24 inches and larger were particularly difficult to kill.

According to checks made 6 years later, most of the trees in all treatments were dead. Treatment efficacy thus was expressed mainly in the speed of the kills rather than in ultimate percentages of kill. The little sprouting that had occurred on red maple was browsed by deer.

Considering cost, effectiveness, and ease of application, chemical frill-girdling was rated as superior to machine girdling. The men found the machine heavy, uncomfortable, and tiring. Among the herbicidal treatments, sodium arsenite in complete frills provided the best all-around results. However, extreme care must be exercised with sodium arsenite at all times.

A COMMERCIAL SIZE CULTURAL OPERATION--1963

Procedures

With funds made available by the Accelerated Public Works program (APW), cultural work in the management study was enlarged to a commercial-size scale. One specified treatment was applied on 375 acres to control unwanted trees.

Funds became available for the local program in September, 1963. The cultural work started immediately and continued through December 1963. Because of our success with sodium arsenite in the exploratory treatments and because the chemical appeared to be effective year-round in our northern forests, we used it exclusively in the 1963 experiments.

The work was done by experienced men. Each of the five men hired for the job had worked previously on various kinds of stand improvement operations during summer and winter seasons, and had some experience in frill-girdling with sodium arsenite.

The acreage to be treated was mapped into 24 subcompartments ranging in size from 8 to 28 acres. This helped in organizing the job. Up to one-third of the merchantable volume had been harvested from the subcompartments a few years earlier. Parts of some of them had also received cultural work in the exploratory treatments.

Unlike the exploratory treatments, the 1963 operation was heavily concentrated on sapling and poletimber trees in addition to those of larger size. Many of the unwanted trees 6 inches d.b.h. and larger had been marked during the previous timber-marking operations. Among trees less than 6 inches d.b.h., selections for treatment were made by the axmen. In addition to having received direct field training in selecting trees for treatment, the men had some supervision by the forester-in-charge as the operation progressed. However, one man acted as foreman most of the time, and he handled the operation quite well.

The five workers were divided into 2- and 3-man crews. In the 2-man crew, one man made frills and the other applied the sodium arsenite; in the 3-man crew, two men made the frills and the third man applied the chemical. Deep, complete frills were made on all trees except the smaller saplings; these usually were cut down and the sodium arsenite was applied to the stumps. The crews worked abreast each other, traversing the units in strips.

Axes of several weights were tried, but a 2½-pound cruising ax was found most satisfactory for the range of tree sizes in this operation. A 1-pint plastic squeeze bottle was used for dispensing the sodium arsenite solution. A 1-gallon plastic storage bottle was also carried by one of the men in each crew. Maximum safety precautions were exercised at all times. The men dispensing the chemical rubbed protective cream on their hands, and wore rubber gloves and protective goggles.

On each subcompartment, daily time records were kept by the foreman to the nearest half-hour. The amount of arsenite solution used was also recorded. Because of APW restrictions, no tree measurements were taken during the cultural operation. These were done on a 100-percent tally basis during the summer of 1964. At the same time, observations were made on the first-year effectiveness of the treatment.

Results

Operational data for the job are summarized in table 3. The time per acre ranged from 1.3 to 7.1 man-hours, and averaged 4.3 man-hours. Costs per acre for labor and chemical ranged from $2.56 to $14.49, and averaged $8.79.

Beech was by far the predominant species treated. Because of the high proportion of this low-value species in the stands, it was poisoned to favor more valuable species whenever possible. Other species treated included: red maple, sugar maple, yellow birch, paper birch, white ash, striped maple, pin cherry, hemlock, and spruce. Although trees in all size classes were treated, small trees made up the highest percentage. The average tree size was only 3.1 inches d.b.h., and the largest tree was a 42-inch d.b.h. red maple.

By keeping an accurate record of man-hours and trees treated for each of the 24 units separately, we were able to develop two sets of regression equations for use in estimating labor requirements on similar cultural operations.

The more precise equation is based on square feet of basal area per acre by two diameter groups. The equation is:

$$Y = 1.20 - 0.008X_1 + 0.535X_2$$

where Y is estimated frill-girdling time in man-hours (exclusive of travel time to and from the work area), X_1 is basal area per acre in trees 6 inches d.b.h. and larger, and X_2 is basal area in trees 4 inches d.b.h. and smaller. The independent variables (basal areas) in this equation account for 85 percent of the variation in man-hours. The standard error of estimate is ± 0.66 man-hours per acre.

The less precise equation is:

$$Y = 1.31 + 0.0048X$$

where Y is estimated frill girdling time in man-hours exclusive of travel time to and from the work area, and X is the product of the average size of

The quantity of chemical solution required per acre is estimated from the regression equation:

$$Y = 0.09 + 0.0005X$$

where Y is the estimated gallons per acre and X is the product of the average size of treated trees multiplied by the number of trees treated per acre.

The latter equations are very close to those developed on a frill-girdling operation in northern hardwoods in the Adirondacks.[5]

Although it is too soon to appraise the effectiveness of the 1963 operation, observations made during the first growing season after treatment indicated that sodium arsenite works more slowly in autumn than in summer applications. The slowness was especially apparent on large sawtimber-size trees of yellow birch, red maple, and sugar maple. However, some crown damage was evident. The few paper birch trees that were treated showed practically no signs of damage.

Most large trees treated in October showed less effect than those treated in September, November, or December. During October the birches and maples bled profusely from the ax cuts, and this may have washed out much of the chemical. However, complete kills or heavy damage occurred in trees smaller than about 12 inches d.b.h.

Further observations will be made during the next 2 years to evaluate more fully the effectiveness of this cultural operation.

Table 1.--Application data for the treatments

Treatment	Area treated	Basal area treated per acre	Average d.b.h.	Labor	
				Per acre	Per sq. ft.
	Acres	Sq. ft.	In.	Man-hrs.	Man-hrs.
Machine girdling	79	5.1	13	1.2	0.24
Complete chemical frill-girdling					
2,4,5-T	30	7.3	10	2.1	.29
2,4-D--2,4,5-T(SA)[1]	52	7.1	11	2.0	.28
2,4-D--2,4,5-T(DA)[2]	12	7.7	12	1.8	.23
Sodium arsenite	28	5.8	13	1.8	.31
Partial chemical frill-girdling					
2,4,5-T	33	6.1	9	1.3	.21
Sodium arsenite	33	9.2	14	1.4	.15

[1] Single application: 1 pass around frill.

[2] Double application: 2 passes around frill.

[5] Curtis, Robert O. Estimating costs of improving Adirondack timber stands by killing culls with frills and sodium arsenite. Northeast. Forest Expt. Sta., Forest Res. Note 63. 4 pp., 1956.

Table 2.--Effectiveness of treatments after 2 years

Treatment	Stems killed	Stems damaged[1]	Stems undamaged
	Percent	Percent	Percent
Machine girdling	51	47	2
Complete chemical frill-girdling			
2,4,5-T	62	38	0
2,4-D--2,4,5-T (SA)[2]	82	18	0
2,4,-D--2,4,5-T (DA)[3]	82	18	0
Sodium arsenite	99	1	0
Partial chemical frill-girdling			
2,4,5-T	12	41	47
Sodium arsenite	83	16	1

[1] A tree was considered damaged if at least one-third of the crown was killed.

[2] Single application: 1 pass around frill.

[3] Double application: 2 passes around frill.

Table 3.--Operational data for the 1963 chemical frill-girdling on a per-acre basis.

Item	Range		Weighted average
	Lowest	Highest	
Man-hours	1.3	7.1	4.3
Basal area (square feet)	1.2	19.4	11.4
Trees (number)	45.0	381.6	194.0
Silvicide (pints)	.6	5.4	3.3
Cost			
Labor[1]	$2.41	$13.14	$7.96
Sodium arsenite[2]	.15	1.35	.83
Total	$2.56	$14.49	$8.79

[1] Labor: $1.85 per man-hour.

[2] Sodium arsenite: 25¢ per pint ($10.00 per 5-gallon can).

PELLETED HERBICIDES - THEIR POTENTIAL IN FOREST SITE CONVERSION

R. D. Shipman and J. P. Eichert [1]

The use of liquid herbicides to control unwanted vegetation is an accepted practice among most federal, state, private and industrial forest managers. In general, the use of any given formulation has been geared to a specific silvicultural objective when dealing with forest stands of varying ages.

In the South and southeastern states, liquid herbicides have been applied extensively in forest stands as stump and basal sprays, foliage applications and as basal cuts with various types of tree injectors, to name but a few. The silvicultural objectives have been aimed at freeing or releasing established tree seedlings and saplings from overhead competition and to improve the growth of residual trees after treatment. As a corollary treatment, liquid herbicides have also been useful in controlling hardwoods to create more growing space and improved site conditions for seedling survival and growth. In short, liquid herbicides as used in the southern United States are compatible with the two major forest management systems, even-aged and all-aged production of timber, where emphasis has been placed upon removal of undesirable hardwoods to favor the fast-growing pines.

In contrast, liquid herbicide use in the Northeast for forest production and stand improvement has been limited, as dictated primarily by a more complicated set of site conditions, species mixtures, and timber usages. Traditionally, in states like Pennsylvania, managers of public and private lands have leaned toward the so-called "selection" method of stand improvement, i.e., removing individual mature trees and leaving the younger trees (both pine and hardwood) to develop.

However, there is increasing evidence available that the majority of our intermediate-age stands of hardwoods in the Northeast might be harvested more economically with even-aged management practices. It now seems evident that, except for certain areas like those of poor internal soil profile drainage, or steep, erosive areas, mature hardwood stands, to be reproduced to hardwoods or converted to conifers, should be considered for a clean, heavy regeneration cutting as the timber is harvested.

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It is at this point in the management system, namely "clearcutting mature stands to regenerate them from the advance reproduction present", that pelleted herbicides may enter the management picture -- pelleted herbicides as (1) a possible tool in controlling hardwood sprouts after clearcutting to induce natural hardwood regeneration, or (2) complete site conversion to coniferous or other desirable species by artificial means (planting or seeding).

In light of the above objectives of a changing hardwood forest management policy, particularly in moving towards even-aged management in the Northeast, a study was initiated in the spring of 1964 to test the performance of pelleted and liquid herbicides in converting low value all-aged hardwood stands to even-aged pine. From a long range viewpoint, this investigation can be arbitrarily broken down into the following phases. The early results obtained from phases 1 and 2 only are presented in this paper:

1. An evaluation of the response of various uncut hardwood trees, shrubs, and sprout vegetation following soil-surface applied pelleted herbicides. A similar evaluation will compare the response obtained using liquid 2,4,5-T applied with a tree injector under the same site conditions.

2. An evaluation of the effect of pelleted herbicides on the survival and vigor of underplanted pine seedlings, when pellets are soil applied by broadcast and individual tree methods at the time of planting or soon thereafter.

3. A determination of the influence of environmental factors such as soil moisture, light, prescribed fire, and soil type on the residual effects of pelleted herbicides applied to the soil at various rates.

4. To determine the plant successional changes occurring on the forest floor according to number and kind as influenced by the various herbicide treatments.

5. Finally, to develop a site conversion cost analysis based upon stand structure, herbicide type and formulation, degree of hardwood control, and seedling susceptibility.

STUDY METHODS

The experimental areas selected for long term investigation are representative of the oak-hickory forest type occurring in central Pennsylvania. About 73 percent of the commercial forest land in the state is classified in this category -- containing mostly low quality slow growing pole-sized hardwood timber, often 45-50 years of age or more. It is precisely this class of timber that may lend itself most economically to complete stand conversion, eventual shortening of the tree rotation, and towards even-aged management procedures.

Location

Field installations were established in a randomized block arrangement in the spring of 1964 at three localities in Pennsylvania. Each block contained twenty, 1 square chain subplots. The geographical location of these plots and their corresponding soil types are: (1) Stone Valley Experimental Forest, Huntingdon County -- Gilpin shale loam; (2) The Barrens, Centre County -- Morrison sandy loam; and (3) Black Moshannon State Forest, Centre County, a Dekalb sandy loam. Some estimate of the predominantly oak stand (white, scarlet and chestnut) according to stand structure and size at the time of treatment can be visualized from the following data:

Diameter class Inches	Block Location: Stone Valley No. stems	The Barrens No. stems	Black Moshannon No. stems
1	632	133	852
2	266	163	252
3	158	235	190
4	119	206	207
5	92	168	222
6	104	112	172
7	92	115	100
8	68	55	58
9	53	24	28
10	41	15	16
11	18	6	9
12	15	4	6
13	2	1	4
14	2	3	1
15+	2	0	3
No. competing stems 1" in diameter and up per acre	832	620	1060

Treatment

At each experimental location, and approximately one month in advance of herbicide application, three-year old red pine and two-year old white pine seedlings were planted by hand among the hardwoods at a 6 x 6 foot spacing. At the Black Moshannon site, a prescribed or controlled burn was carried out prior to planting and herbicide treatment.

Three chemical compounds manufactured in pelleted form and one as a granular material were applied to the soil surface in an effort to simultaneously control the unwanted hardwood overstory and to release the planted pine. The pelleted and granular formulations and their corresponding active ingredients applied as treatments on the soil surface were:

Herbicide	Active Ingredient	Generic-Trade Name
3-phenyl-1, 1-dimethylurea	25% pellets	fenuron (Dybar)
4-amino-3, 5, 6-trichloropicolinic acid	10% pellets	-- (Tordon)
3-phenyl-1, 1-dimethylurea trichloroacetate	22% pellets	fenuron TCA (Urab)
2-methoxy-3, 6-dichlorobenzoic acid	10% granules	mediben (Banvel-D)

In order to evaluate the effectiveness of a given herbicide in terms of invested costs of conversion, all pelleted and granular materials were broadcast at 20 and 40 lb/A rates on a weight basis. Where pellets were scattered on the soil around the base of individual trees, the amount applied was determined according to tree diameter, and the number of stems per unit area governed the total amount applied.

FIRST-YEAR RESULTS

At the end of the first growing season, a complete inventory of all trees 1" in diameter and up, including the injector-treated trees, was made, or a total of 5,024 stems. These trees were appraised according to their degree of kill into four categories: 1 -- readily susceptible (dead), 2 -- susceptible (nearly dead), 3 -- moderately susceptible (50-50 chance of dying) and 4 -- resistant (no affect).

In October, after the period of active growth, a similar tally was taken on all underplanted seedlings, ranking them according to their degree of susceptibility to the various pelleted herbicide treatments, and singling out other effects on the seedlings such as poor planting, deer damage or drought.

The first-year treatment mean values are presented in Tables 1 and 2. Each of the three plot locations was analyzed statistically to determine the significance of the individual herbicide treatment and its effect upon the overstory control and herbicidal resistance of the planted seedlings. An interpretation of the statistical data after the first growing season can be given as follows:

Hardwood Control - Pellets

I. Black Moshannon:

Highly significant differences (1 percent level) among the various treatments were apparent. A table of mean differences between treatments showed that fenuron applied at rates of 20 and 40 pounds per acre broadcast on burned plots, gave significantly better overstory control than Tordon at the same rates. There were no significant differences between fenuron treatments applied at 20 or 40 pounds per acre.

Least significant difference between any two means:

Ref. Table 1 - L.S.D. .05 = 7.2%

II. Stone Valley:

Highly significant differences (1 percent level) occurred among the various hardwood control treatments. A table of mean differences between treatments indicate the superiority of fenuron (applied either broadcast or circumbasally) over Tordon without prescribed burning. Least significant difference between any two means:

Ref. Table 1 - L.S.D. .05 = 4.4%
L.S.D. .01 = 9.5%

III. The Barrens:

Similar to the results of the two previous blocks, highly significant differences (1 percent level) were evident among the four pelleted herbicide treatments. Mean differences between and among the four materials and their control percentages indicate the significance of fenuron and fenuron TCA over Tordon and mediben in these trials. There appeared to be nc real differences in control between fenuron and fenuron TCA, both of which were superior to Tordon and mediben at the rates which the comparisons were made. The least significant differences between any two means were:

Ref. Table 1 - L.S.D. .05 = 6.7%
L.S.D. .01 = 12.3%

Hardwood Control - Tree Injector

The consistent results obtained at all three locations where the tree injector was used to control the hardwood overstory is apparent from the data given in Table 2. A statistical analysis (not presented here) of the data means indicated the marked significance of using connected hacks to achieve the maximum kill. The generally low overall kill for the best treatments can be attributed in part to an extremely prolonged drought period following the spring application. There appeared to be some advantage in the use of a wide (3 inch) blade and doubling the concentration of 2,4,5-T per hack when using the connected hack method. However, the effects of blade width and increased concentration were not of statistical significance after the first growing season. A more critical examination of these techniques will be made in the spring of 1965.

Seedling Survival

Although a statistical analysis of the relationship between the herbicidal effects and seedling survival has not been completed at this time, several important trends have appeared after the first year's trials. In most instances, an inverse relationship between the rate of chemical applied and seedling survival is apparent, i.e., high rates of application result in decreased seedling survival. Nonetheless, the

Table 1. Relation between hardwood overstory kill and pine seedling survival following application of four pelleted herbicides (after one growing season)

Herbicide	lbs. a.i. per acre	Application method[1]	Location[2] I Mean kill percent	I Seedling survival percent	II Mean kill percent	II Seedling survival percent	III Mean kill percent	III Seedling survival percent
fenuron	10	BB	95	66				
fenuron	5	BB	89	80				
Tordon	4	B	68	70				
fenuron	10	B	67	66				
Tordon	4	BB	66	70				
fenuron	5	B	63	85				
Tordon	2	BB	58	76				
Tordon	2	B	36	85				
fenuron	10	C(h)			95	88		
fenuron	10	B			92	66		
fenuron	3.5	C(1)			81	86		
Tordon	4	B			76	74		
fenuron	5	B			66	86		
Tordon	6.5	C(h)			63	87		
Tordon	2	B			45	84		
Tordon	2.1	C(1)			38	87		
fenuron	10	B					98	65
fenuron TCA	8.8	B					95	89
fenuron	14	C(h)					94	92
fenuron	10	C(1)					93	91
fenuron TCA	17.5	C(h)					83	88
fenuron	5	B					82	80
fenuron TCA	9.9	C(1)					61	97
fenuron TCA	4.4	B					48	94
Tordon	8	C(h)					34	86
Tordon	2	B					19	84
mediben	4	B					17	88
mediben	4.5	C(1)					13	94
mediben	4.5	C(h)					13	95
Tordon	5.5	C(1)					9	92
mediben	2	B					6	93
Tordon	4	B					5	89

[1] BB - Prescribed burn - broadcast
B - Broadcast
C - Circumbasal
(h) - high

[2] I - Black Moshannon
II - Stone Valley
III - The Barrens

Table 2. Seedling survival, degree of hardwood kill, and its relation to cut-surface application of 2,4,5-T with a tree injector (after one growing season)

	Treatment [1]							
	A		B		C		D	
Plot location	Dead percent	Seedling survival	Dead percent	Seedling survival	Dead percent	Seedling survival	Dead percent	Seedling survival
Stone Valley	32	98	13	99	32	96	14	97
The Barrens	86	100	19	96	95	96	7	89
Black Moshannon	62	100	7	95	24	98	26	90
Mean all locations	60	99	13	97	50	96	16	95

[1] Treatment

Injector variables*

A - 3" bit, connected hack, 2 ml/stroke
B - 3" bit, no. cuts/2" dia., 2 ml/stroke
C - 2" bit, connected hack, 1 ml/stroke
D - 2" bit, no. cuts/2" dia., 1 ml/stroke

* Using a 5% by volume mixture of 2,4,5-T iso-octyl ester in fuel oil.

average survival of both planted species at combined locations and for all pelleted treatments is 84 percent. Red pine seedling survival was approximately 4 percent better than the white pine survival. Assuming as much as a 50 percent mortality after the first growing season (including deer damage, drought, trampling, winter kill etc.) it is estimated that there will remain some 500-600 seedlings sufficient for plantation establishment and adequate site conversion.

SUMMARY

In a study of the prospects for simultaneously converting pole-sized hardwood stands to coniferous plantations, three pelleted and one granular herbicide was scattered on the soil in three dominantly oak stands in Pennsylvania. For comparison, a 5 percent by volume mixture of 2,4,5-T iso-octyl ester in fuel oil applied with a tree injector was used to control hardwoods on the same sites. Underplanted red and white pine seedling survival was extremely high (84 percent) after the first growing season. Ranked in decreasing order of their effectiveness in killing the overstory to release the planted pine, were fenuron, fenuron TCA, Tordon and mediben.

In stands treated with the tree injector, the superiority of connected hacks over spaced hacks with 2,4,5-T ester was evident. The first-year results indicate that, even where high rates of pelleted herbicides are soil applied at the time of planting or soon thereafter, simultaneous conversion of all-aged hardwood stands to even-aged conifers is a possibility.

Further investigations will be carried out to determine the influence of environmental factors and soil residues associated with the application of pelleted herbicides in the site conversion process.

STUDIES ON THE HERBICIDAL ACTIVITY OF PROPANIL

G. Hofstra and C. M. Switzer[1]

Abstract[2]

Propanil (3,4-dichloropropionanilide) is used widely at rates of 3 to 6 lb/A for selective weed control in rice. Potatoes and tomatoes, while not as resistant as rice, have been found to be more tolerant to propanil than are many common weeds. However, at the rates used in these crops (3/4 to 2 lb/A) there is considerable variability in the response of both weeds and crop plants to this chemical. The present study was undertaken to determine the signifance of several factors on the activity of propanil, and, if possible, to determine the mechanism of phytotoxicity.

Several species of plants sprayed with propanil were rated as (a) susceptible: wild buckwheat, lamb's quarters, red-root pigweed, smartweed, soybean and kidney bean; (b) intermediate: corn, purslane, (c) resistant: potato, tomato, cucumber, dandelion, field bindweed, prickly lettuce, milkweed, wild carrot, and perennial sow thistle.

Various methods of spray application were studied in the greenhouse and in the field using tomato and lamb's quarters plants. Spraying the lower leaf surface only was slightly more effective than spraying the upper surface only. Spraying at night also was slightly more effective than spraying during the day. There was no difference in plant response when sprayer pressures ranging from 10 to 150 psi were used as long as good coverage was obtained. Injury from propanil was locallized indicating that there was little or no translocation.

Propanil injury was of two types. A burning effect occurred within 24 hours of spraying with high concentrations. At lower concentrations injury appeared 4 to 5 days after treatment as water-soaked regions in the centre of chlorotic spots. The whole area became necrotic a few days later. Resistant species frequently showed a reduction in growth.

Membrane permeability was affected by propanil as shown by anthocyanin release from beet root tissue. Extracted chlorophyll was not affected but isolated chloroplasts were broken down rapidly by low concentrations of propanil.

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2) Paper to be submitted to Weeds, the Journal of the Weed Society of America.

Growth of tomato radicles was greatly reduced by low concentrations of propanil (over 60% inhibition by 20 ppm). This concentration had no effect on the elongation of oat coleoptiles unless IAA was added. IAA-induced growth was reduced by propanil indicating that it might be acting as an anti-auxin. However, application of the Lineweaver-Burk treatment to the data indicated that the interaction between propanil and IAA was probably an indirect one.

The respiration rate of leaves of susceptible plants was increased by in vitro treatment with propanil at low rates (less than 75 ppm). At higher rates a marked decrease in oxygen uptake was noted. Respiration of sprayed lamb's quarters plants steadily decreased to about 50% of control after four days.

Isolated plant mitochondria were apparently unaffected by in vitro treatment with propanil up to 40 ppm. Above 40 ppm both oxygen uptake and phosphate fixation were found to be strongly inhibited. The greater effect was on phosphate fixation which was completely inhibited by 75 ppm propanil. Respiration was reduced 30 to 40% by this concentration. Possibly this effect is a critical one in the herbicidal action of propanil.

PREEMERGENCE AND BROADLEAF HERBICIDE EFFECTS ON TURFGRASS ESTABLISHMENT[1]

J. A. Jagschitz and C. R. Skogley[2]

Herbicides for the selective control of broadleaved weeds and crabgrass are frequently used in turfgrass management programs. Many herbicides can be used safely and effectively on established, mature stands of turf. Questions that are constantly raised, however, relate to the safety of the herbicides on seedling turf and time interval required between chemical application and reseeding.

To determine how some of the new and older herbicides affect turfgrass seedings and seedlings, three tests were initiated at the turfgrass research area of the Rhode Island Agricultural Experiment Station.

Test No 1 (November 5, 1963)

This test was designed to determine the effect of fall applied herbicides upon subsequent turf establishment from spring seeding.

Materials and Methods

The experimental design involved two randomized complete blocks. Eight herbicide treatments were applied to a prepared seedbed on November 5, 1963 (Table 1). Individual plot size was three by four feet. Granular materials were applied by hand. Sprays were applied at the rate of 54 gallons of water to the acre. The area was limed and fertilized in late October and sterilized with Vapan. Lime was applied at the rate of 65 lb per 1000 square feet and the area was fertilized at the rate of 2 lb N per 1000 sq ft using a 10-20-10 grade fertilizer.

The area was seeded on June 11, 1964, six months after herbicide application, using a seed mixture containing 48% creeping red fescue, 24% Merion Kentucky bluegrass, 24% Kentucky bluegrass and 4% Astoria Colonial bentgrass. The seeding rate was 4 lb per 1000 square feet. The area was irrigated to maintain adequate soil moisture and mowed to a height of 1½ inches during the test.

Visual percent turf stand estimates were made at several intervals after seeding.

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Results and Discussion

Data on percent turf stand 6, 11 and 19 weeks after seeding are presented in Table 1. Although results vary greatly and lack statistical significance, there were differences of as much as 50% in turf stand between treatments.

Table 1. The percent turf stand from a spring seeding in soils treated the previous fall with various herbicides.

Trt No	Herbicide	ai and formulation	lb ai/A	PERCENT TURF STAND Weeks after seeding 6	11	19
1	Azak	5% Gran	10	40	64	89
2	Betasan	5% Verm	15	53	86	98
3	"	" "	30	31	58	86
4	DCPA	4.1% Verm	10	63	81	96
5	DMPA	4.4% Cob	15	49	71	94
6	Dicamba *	4#/gal	1	80	88	99
7	2-(MCPP) *	"	3	80	88	100
8	Silvex xx	"	1½	85	93	99
9	Check			84	90	99
	LSD 5%			NS	NS	NS

* dimethylamine xx butoxy ethanol ester

Dicamba, 2-(MCPP) and silvex applied in the fall had little effect on turfgrass establishment the following spring. The preemergent type herbicides, Azak, Betasan, DCPA (Dacthal) and DMPA (Zytron) showed a reduction in turf stand. Six weeks after seeding they all had at least 20% less turf stand than the check which had 84% stand. Germination took place in the Azak and Betasan treated plots, but the seedlings were stunted and yellow. Smaller differences were noted eleven and nineteen weeks after seeding but it was still evident that Azak and the 30-lb rate of Betasan reduced turf stand.

Test No 2 (July 28, 1964)

This test was set up to determine the effect of various herbicides applied to seedling turf.

Materials and Methods

The area involved was an unused portion of the turf seeded on June 11, 1963 for Test No 1. The experimental design consisted of two randomized complete

blocks. Fourteen herbicide treatments were applied on July 28, 1964 (Table 2). Individual plot size was three by four feet. Granular materials were applied by hand. Liquid materials were applied as sprays in water at the rate of 54 gallons to the acre using a pressure regulated hand sprayer.

The turf at the time of treatment consisted of creeping red fescue, Merion and common Kentucky bluegrass and Astoria Colonial bentgrass that had been seeded forty-seven days earlier. The turf had been mowed twice prior to treatment.

Visual turf discoloration estimates were made at various intervals after herbicide application. The scale used was 0-5 with 0 being no discoloration and 5 complete brown. Visual percent turf stand estimates were made before treatment and at the end of the season on October 22, 1964.

Results and Discussion

Turf discoloration and percent turf stand estimates made after herbicides were applied to seedling turf are presented in Table 2. All broadleaf weed control herbicides initially caused slight discoloration of the turf. This discoloration was chiefly a light greening of the grass. Dicamba and silvex produced objectionable and significantly greater turf discoloration than 2,4-D, 2,4,5-T, 2-(MCPP) and picolinic acid. Turf treated with dicamba recovered more quickly than that of silvex. At the end of twelve weeks silvex treated plots showed a slight reduction in turf stand.

Table 2. Turf discoloration and percent turf stand after applying various herbicides to seedling turf in the spring.

Trt No	Herbicide treatment	ai and formulation		lb ai/A	TURF DISCOLORATION Weeks after trt 2	3	4	9	% TURF STAND 1 wk before trt	12 wks after trt
1	Azak	5%	Verm	10	.4	.4	.4	.3	80	99
2	Bandane	10%	Verm	35	.2	.3	.5	.3	83	98
3	Betasan	7%	Cob	15	.2	.0	.0	.0	90	96
4	DCPA	2.5%	Clay	10	.4	.8	.9	.8	85	88
5	DMPA	4.4%	Cob	15	.9	2.5	2.3	3.5	85	58
6	EL-110	1.15%	Verm	2	1.3	2.3	2.8	2.3	88	78
7	Trifluralin	.86%	Verm	1½	2.0	3.5	3.7	4.0	85	45
8	Tupersan	4.04%	Verm	9	.1	.0	.0	.0	85	100
9	2,4-D xx	4#/gal		1½	.6	.0	.3	.0	85	98
10	2,4,5-T xx	"		1½	.6	.0	.2	.0	88	100
11	2-(MCPP) *	"		2	.5	.2	.0	.0	78	99
12	Dicamba *	"		1	2.5	1.1	.4	.2	88	97
13	Picolinic acid k	2#/gal		¼	.5	.3	.2	.2	88	99
14	Silvex xx	4#/gal		1½	2.8	2.5	1.3	.6	85	92
15-16	Check				.2	0	0	.1	77	99
	LSD 5%				.4	.7	.7	.6	NS	11
	1%				.6	.9	1.0	.8		16

Azak, Bandane, Betasan and Tupersan, preemergent type herbicides, did not produce objectionable discoloration or a reduction in turf stand during the first twelve weeks after treatment. These plots will be observed in 1965 to determine if injury is delayed. Work reported last year[3] showed little effect of a Betasan granular formulation on seedling turf during the season of application. However the following spring it was noted that there was some reduction in turf stand.

Trifluralin, EL-110, DMPA (Zytron) and DCPA (Dacthal) produced objectionable and significantly greater turf discoloration than the check. The turf stand after 12 weeks was 45%, 58% and 78% for trifluralin, EL-110 and DMPA. This was a significant reduction compared to the check stand of 99%. It appeared that the stands of fescue and bluegrass were thinned in these plots and the bentgrass was not firmly rooted.

Test No 3 (May 21, 1964)

This test was designed to determine what effects various herbicides would have on turf establishment when they were applied at seeding time and when seeding was delayed for various intervals following herbicide treatment.

Materials and Methods

The first group of herbicides (Trt Nos 1-10) were applied to a prepared seedbed on May 22, 1964. In another portion of the seedbed six other herbicides (Trt Nos 11-16) were also applied. Both experimental designs were split-plot. The seeding dates were split. Table 3 lists the herbicides used and the time of seeding after herbicide application. The 0 seeding date was where the seeding was made the day before herbicide application. Two blocks were used for each herbicide group. Sub-plots measured three by four feet.

Granular herbicides were applied by hand. Liquid formulations were applied as sprays in water at the rate of 54 gallons to the acre with the exception of 64-125 which was applied in 272 gallons of water per acre.

The area was limed (70 lb per 1000 square feet), fertilized (20 lb of a 10-20-10 fertilizer per 1000 square feet) and sterilized using Vapan on May 1, 1964.

At each seeding date the soil was loosened with an iron rake to a depth of one inch, seeded, seed raked in and rolled. The seed mixture was similar to that used in Test Nos 1 and 2. The seeding rate was 5 lb per 1000 square feet.

Visual turf stand estimates were made at several intervals after seeding. Observations were also made of the grass specie most affected.

Results and Discussion

Turf stand estimates made four and eight weeks after seeding at various times after soil treatment with herbicides are presented in Table 3. Of the six broadleaf weed control herbicides used, only 2,4-D did not significantly reduce turfgrass stand. The results of this test indicate that 2,4-D can safely be applied at the time of seeding and seedings can be made as soon as two weeks after soil is treated with 2,4-D.

After four weeks in the soil, turf stand was not significantly reduced by dicamba and picolinic acid. Silvex, 2,4,5-T and 2-(MCPP) still showed significantly reduced turf stands from seedings made four weeks after chemical application. After eight weeks growth, 2,4,5-T plots filled in, but the silvex and 2-(MCPP) plots were still significantly reduced. Had the weed control rate of 2-(MCPP) been used (1-2 lb) instead of the 4-lb rate in this test, turf reduction may not have been so evident.

Seedlings in the silvex and 2-(MCPP) plots were stunted and yellow in color. The seedlings in the picolinic acid plots were severely twisted, but the stand was good. There appeared to be some thinning of bluegrass from 2,4,5-T, some bentgrass thinning from picolinic acid and some bluegrass and fescue thinning from silvex.

Of the ten preemergent type herbicide treatments, only Tupersan did not significantly reduce turf stands at any time. Tupersan was safely applied at the time of seeding. After Tupersan was in the soil for four weeks, seedings were safely made. No consistent significant differences were noted between the three formulations of Tupersan.

Azak, Betasan, DCPA (Dacthal) and DMPA (Zytron) showed a significant reduction in turf stand from seedings made up to sixteen weeks after the herbicide was applied to the soil. Seedlings in the Azak and Betasan plots were severely stunted.

Bandane and 64-125 significantly reduced turf stands in seedings made up to ten weeks after herbicide soil application. Turf establishment from sixteen-week seedings was not significantly reduced.

In general turf stands were not reduced as much when Betasan, DCPA and DMPA were applied at seeding time as when seedings were made after the herbicides were in the soil for four weeks. There appeared to be a greater reduction of bentgrass in the Azak, 64-125, DCPA and DMPA plots. Bandane plots had a greater reduction of bentgrass when applied at seeding, but greater fescue and bluegrass reduction when seeded four weeks after Bandane was in the soil. The check plots had about equal proportions of each of the three grass species.

Table 3. Percent turf stand from seedings made in soils treated with herbicides in the spring.

Trt No	Herbicide treatment	ai and formulation	lb ai/A	PERCENT TURF STAND: 4 wks after seeding, Number of weeks chemical in seedbed prior to seeding: 0	2	4	10	16	8 wks after seeding, Number of weeks chemical in seedbed prior to seeding: 0	2	4	10	16
1	Azak	5% Verm	10	5	-	5	3	5	20	-	28	6	14
2	64-125	3/4#/gal	50	14	-	43	4	16	33	-	58	5	63
3	Bandane	10% Verm	35	20	-	7	10	23	75	-	65	47	68
4	Betasan	7% Cob	15	10	-	2	5	2	62	-	6	10	3
5	DCPA	2.5% Clay	10	28	-	5	20	12	65	-	43	78	45
6	DMPA	4.4% Cob	15	15	-	4	5	9	50	-	18	20	30
7	Tupersan	2.34% Fert	4.5	69	-	85	75	32	99	-	98	98	89
8	"	4.04% Verm	4.5	58	-	66	73	19	98	-	98	96	88
9	"	50% WP	4.5	45	-	68	73	33	95	-	94	97	90
10	"	4.04% Verm	9	63	-	73	60	31	99	-	98	97	86
11	Dicamba *	4#/gal	1	20	55	83	-	-	70	97	95	-	-
12	2-(MCPP) *	"	4	13	13	33	-	-	35	50	69	-	-
13	2,4-D xx	"	1.5	53	88	80	-	-	95	98	97	-	-
14	2,4,5-T xx	"	1.5	29	35	60	-	-	80	83	93	-	-
15	Silvex xx	"	1.5	20	20	40	-	-	55	53	74	-	-
16	Picolinic acid k	2#/gal	.25	34	65	78	-	-	93	97	97	-	-
17	Check			56	-	75	65	20	98	-	97	98	78
	LSD	5%		33	11	14	8	NS	21	16	18	19	29
		1%		45	17	19	11	NS	29	24	25	27	41

* dimethylamine xx butoxy ethanol ester k potassium salt - no seeding made

Conclusions

Based on the results of these three tests, the following conclusions may be reached:

1. Turfgrass stands from spring seedings were less in soils treated in the fall with Azak, Betasan, DCPA (Dacthal) and DMPA (Zytron). No reduction was evident from soil treated with dicamba, silvex and 2-(MCPP).

2. Soils treated in the spring with Azak, Betasan, DCPA and DMPA had significantly less turfgrass from seedings made up to sixteen weeks after herbicide application. Bandane and 64-125 significantly reduced stands from seedings made up to ten weeks.

3. Tupersan and 2,4-D applied in the spring did not affect turf stands from seedings made the day before or after herbicide application.

4. After four weeks in the soil, seedings were successfully made after the spring application of dicamba and picolinic acid. Some turf reduction was still evident from soil treated with 2,4,5-T, silvex and 2-(MCPP) (4-lb rate).

5. DCPA, Dicamba, DMPA, EL-110, Silvex and Trifluralin caused objectionable and significant discoloration of seedling turf. DMPA, EL-110 and trifluralin significantly reduced turf stands.

6. Seedling turf treated with Azak, Bandane, Betasan, 2,4-D, 2,4,5-T, 2-(MCPP) and picolinic acid was slightly discolored.

Appendix

The chemical name and source of the herbicides used in this test are as follows:

Azak = 2,6-di-tert-butyl-p-tolyl-methylcarbamate (Hercules); Bandane = Polychlorodicyclopentadiene isomers (Velsicol); Betasan = N-(beta-O,O-diisopropyl-dithiophosphorylethyl)-benzene sulfonamide (Stauffer); DCPA (Dacthal) = dimethyl 2,3,5,6-tetrachloroterephthalate (Diamond Alkali); DMPA (Zytron) = O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate (Dow); Dicamba (Banvel D) = 2-methoxy-3,6-dichlorobenzoic acid (Velsicol); 2,4-D = 2,4-dichlorophenoxyacetic acid (Amchem); 2,4,5-T = 2,4,5-trichlorophenoxyacetic acid (Amchem); 2-(MCPP) = 2-(2-methyl-4-chlorophenoxy) propionic acid (Chipman); EL-110 = an analog of trifluralin (Eli Lilly); 64-125 = Dinoben isomer by-product (Amchem); Picolinic acid (Tordon) = the K salt of 4-amino-3,5,6 trichloropicolinic acid (Dow); Silvex = 2-(2,4,5-trichlorophenoxy) propionic acid (Amchem); Trifluralin (Treflan) = a,a,a-trifluoro-2,6-dinitro-N,N dipropyl-

THE CONTROL OF CRABGRASS IN LAWN TURF WITH PREEMERGENCE HERBICIDES[1]

C. R. Skogley and J. A. Jagschitz[2]

Crabgrass control with preemergence herbicides has become an accepted practice. The number of users and available chemicals have both increased rapidly in recent years. Since new chemicals and formulations continue to appear and the conditions of use vary from season to season and location to location, it is necessary to maintain an annual evaluation program. In this manner it is hoped that the consistently safe and effective herbicides can be isolated.

Materials and Methods

Three field studies were planned and executed during 1964 for the purpose of gaining new or supporting information relative to the performance of many preemergence crabgrass herbicides. All three experiments were located on Bridgehampton silt loam soils at the turfgrass research area of the Experiment Station.

Test number 1 was established on a one-year-old stand of turf estimated to consist of 20 percent Colonial bentgrass (*Agrostis tenuis* Sibth.), 35 percent Kentucky bluegrass (*Poa pratensis* L.), 35 percent creeping red fescue (*Festuca rubra* L.) and 10 percent Italian ryegrass (*Lolium multiflorum* Lam.). The test area was overseeded with smooth crabgrass (*Digitaria ischaemum* (Schreb.)) in December of 1963.

One hundred and two chemical treatments and six checks were included and were completely randomized in each of three blocks. Plot size was 4 by 8 feet. Herbicides were applied between the dates of April 21 and 28, 1964.

Emulsifiable concentrate and wettable powder formulations were mixed with water and, except as noted in table 1, were applied at the rate of 272 gallons per acre. A two-gallon, pressure regulated hand sprayer, adjusted to deliver at 30 psi was used to make the applications. Dry materials were applied by hand or, as indicated for treatments 96, 97 and 98, with a mechanical spreader.

The area was mowed regularly at a height of 3/4 inch and was watered frequently during the season. A 10-6-4 grade fertilizer was applied on July 28 at a rate of 10 pounds per 1000 square feet. Clippings were not removed from the plots at any time.

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Crabgrass plants in the two- to six-leaf stage were evident on June 29, averaging 9 plants per square foot in the check plots. The number of plants had increased to 16 on July 16th and to 17 by August 7th.

Test number 2 was established as a residual test that will involve a three-year study. Seven chemical treatments and one check were completely randomized six times within each of three blocks making a total of 18 replicates for each treatment.

The test area was seeded on September 16, 1963 with a seed mixture containing 50 percent creeping red fescue and 50 percent Kentucky bluegrass. The area was aero-thatched and overseeded with crabgrass on May 19, 1964. All chemicals were applied by hand on May 21. The cutting height during the season was 3/4 inch and clippings were not removed. The area was irrigated frequently to insure crabgrass germination. A 3-2-1 ratio fertilizer at a rate to supply 2 lb of N/1000 sq ft was applied on July 8.

Some crabgrass germination was noted on June 1 and by the 26th there was an average of 192 plants per square foot on the check plots. By July 16 the average number of crabgrass plants had increased to 272 per square foot.

In past seasons it had been variously noted at this station that the effectiveness of many of the preemergence herbicides may be influenced by the density of the stand of turfgrass. In certain instances the control decreased with a decrease in turf density. Test number 3 was established to investigate this possibility.

An area of young, thin turf was selected for one-half of the trial. This area was comparable to that used for test number 1. The other half of the study was located on an old, dense and matted stand of Kentucky bluegrass. The design of the test consisted of two complete randomized blocks in each of the two locations. Seventeen chemical treatments and two checks were included. Plot size was four by five feet.

The thin-turf area was overseeded with crabgrass in December of 1963. The thatched turf was overseeded with crabgrass on May 4 after first removing some thatch with a Henderson "Thin-Cut", and an aero-thatch machine. A 10-6-4 grade fertilizer was applied at the rate of 10 pounds per 1000 square feet to the thatched turf in April and the thin turf in late July.

All herbicides were applied on May 4. Dry materials were spread by hand and sprays were applied as in test number 1 at 272 gallons per acre. Both areas were watered regularly and mowed to a height of 3/4 inch. Crabgrass seedlings were first observed on the thatched turf on June 2 and on the thin turf on June 29.

All experiments were observed frequently following herbicide application. Turfgrass injury or unusual responses were noted and recorded at 6 or 8 intervals during the season. An estimate of crabgrass coverage on each plot was made during the period from September 22 through 28. Estimates of

The 1964 growing season was abnormally dry but as a result of frequent irrigation a good stand of crabgrass emerged and matured on the check plots in all tests.

Results and Discussion

Table number 1 gives treatment numbers, chemical and formulation, acre rates and average percent crabgrass control, maximum turf injury ratings, and percent bare area for each of the three tests. The chemical names and companies supplying the materials for all tests appear in the Appendix.

As in past seasons excellent control of crabgrass was accomplished by the application of certain herbicides. In general all of the materials being sold at retail as crabgrass preventers were highly effective. In addition certain chemicals being tried at this station for the first or second time gave excellent crabgrass control. Among them were OCS-21944, Azak, EL-110 and Tupersan. Several other materials gave excellent crabgrass control but, because of turf injury, they must be eliminated from further consideration.

Turfgrass injury was more severe during the 1964 season than during most seasons. This may be attributed to the dry season or to the age of stand. Except for the thatched turf in test number 3 all stands were less than a year old. The general soil fertility levels of the young turf were kept low in attempting to maintain a thin stand of turf for improved crabgrass germination. This also might account for the more obvious turf injury particularly in test number 2. The figures for percent bare area given in the table would indicate a final degree of turfgrass injury. In some instances the injury was a temporary leaf burn and in others it increased with time and actually killed some of the grass. Calcium arsenate in test number 2 is an example of early injury while DMPA shows delayed, lasting injury.

Test number 3, designed to determine whether turf density effected chemical control, indicated that density had little bearing on herbicide effectiveness. The degree of crabgrass control was nearly equal on both thatched or thin turf with all herbicides.

Treatments numbered 88 through 94, 66 and 102 were included as a check against a large scale study on highway turf. It was hoped to determine whether certain of the effective crabgrass preventers would remain effective when combined in a spray tank with the growth retardant, maleic hydrazide, and applied at 50 gallons per acre. Herbicide effectiveness appeared to be reduced by the combination only with Bandane and trifluralin. Turf injury was greater for each herbicide in combination than when used alone. This could be the result of chemical combination or the low gallonage used. That gallonage may be an important factor is evidenced when comparing treatments 66 and 91.

Conclusions

Three separate and distinct crabgrass control tests were established and evaluated during the 1964 growing season. The following conclusions are drawn based on the results obtained in the three studies:

1. Certain rates and formulations of the following herbicides will effectively control crabgrass: Bandane, Betasan, Azak, DCPA, DMPA, calcium arsenate, Tupersan, Trifluralin, Chlordane, Trifluralin plus Diphenatrile, OCS-21944, ACS-22, EL-110.

2. Azak, Betasan, Tupersan and Trifluralin plus Diphenatrile gave good control with the least turfgrass injury.

3. Turfgrass density and the presence or absence of mat and thatch had little bearing on the effectiveness of herbicides for crabgrass control.

4. Turfgrass injury following herbicide application may be influenced by age of turf stand, soil fertility and soil moisture.

5. Crabgrass control effectiveness is not lessened when Azak, Betasan, DCPA, DMPA or Tupersan is applied in combination with maleic hydrazide. Turf injury was increased by the combination, probably due to low gallonage application.

Appendix

Herbicide	Company	Chemical name
ACS-22	Velsicol	Not indicated
Azak	Hercules	2,6-di-*tert*-butyl-*p*-tolyl methylcarbamate
Bandane	Velsicol	Polychlorodicyclopentadiene isomers
Bandane formulation	O. M. Scotts	12.4% plus fertilizer; F-1201 granular
Betasan	Stauffer	N-(beta-O,O-diisopropyldithiophosphorylethyl)-benzene sulfonamide
Chlordane	Velsicol	Octachloro-4,7-methanotetrahydroindane and related compounds
DCPA (Dacthal)	Diamond Alkali	dimethyl 2,3,5,6-tetrachloroterephthalate
DMPA (Zytron)	Dow	O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate
Diphenatrile	Eli Lilly	Diphenylacetonitrile
EL-110	Eli Lilly	analog of trifluralin
EH 9180	American Cyanamid	Not indicated
EH 52,445	American Cyanamid	Not indicated
H-9573	O. M. Scotts	Azak formulation, F-1266
MH-30	U.S. Rubber	1,2-dihydropyridozine-3,6-dione
OCS-21693	Velsicol	Not indicated
OCS-21944	Velsicol	Not indicated
Pre-San	Mallinckrodt	Betasan formulation - liquid
R-4461	O. M. Scotts	Betasan formulation, F-1267
Tok-2 *	Rohm & Haas	2,4-dichlorophenyl 4-nitrophenyl ether
Calcium arsenate	Allied Chemical	
Trifluralin	Eli Lilly	a,a,a-trifluoro-2,6-dinitro-*N*,*N* dipropyl-*p*-toluidine
Tupersan	DuPont	1-(2-methylcyclohexyl)-3-phenylurea
UC 22463 *	Union Carbide	3,4,dichlorobenzyl-N-methylcarbamate --80%, 2,3 isomer--20%
64-125	Amchem	Dinoben isomer by-product

* Samples used in 1964 trials were reportedly contaminated or misformulated.

Table 1. Crabgrass control and turfgrass injury in response to the spring application of various herbicides in three separate tests.

TRT NO	CHEMICAL AND FORMULATION	% ai	# ai/A	% CRABGRASS CONTROL (SEPT) TEST 1	2	3 THATCH	3 THIN	MAX TURF INJURY* (APRIL TO SEPT) TEST 1	2	3 THATCH	3 THIN	% BARE (SEPT) TEST 1	2	3 THATCH	3 THIN
1	DCPA (clay)	2.5	10	96	75	99	99	.5	2.1	.5	.9	3	5	0	0
2	DCPA (WP)	75	"	99	--	--	--	1.1	--	--	--	2	--	--	--
3	DMPA (cob)	4.4	15	98	98	99	100	1.5	3.8	.3	1.6	11	43	0	0
4	DMPA (liq)	3#/gal	"	99	--	--	--	1.0	--	--	--	1	--	--	--
5	Ca arsenate (dust)	69.28	382	85	71	100	95	.2	1.8	.5	.8	.3	1	0	0
6	Bandane (Fert)	7.5	35	96	--	--	--	0	--	--	--	0	--	--	--
95	" "	12.4	"	94	--	--	--	0	--	--	--	1	--	--	--
7	Bandane (Verm)	10	"	99	94	94	99	.3	2.5	.3	.1	2	5	0	0
8	Bandane (EC)	4#/gal	"	84	--	--	--	.2	--	--	--	1	--	--	--
99	Chlordane (Verm)	20	90	89	--	--	--	.1	--	--	--	0	--	--	--
9	OCS-21944 (Verm)	5	5	73	--	--	--	.2	--	--	--	0	--	--	--
10	" "	"	7	89	--	--	--	.2	--	--	--	0	--	--	--
11	" "	"	9	95	--	--	--	0	--	--	--	1	--	--	--
12	" "	"	20	98	--	--	--	.7	--	--	--	2	--	--	--
13	OCS-21944 (EC)	1#/gal	5	87	--	--	--	.7	--	--	--	3	--	--	--
14	" "	"	7	96	--	--	--	.4	--	--	--	2	--	--	--
15	" "	"	9	99	--	--	--	1.0	--	--	--	6	--	--	--
16	" "	"	20	99	--	--	--	2.3	--	--	--	4	--	--	--
17	OCS-21693 (Verm)	5	5	81	--	--	--	.1	--	--	--	0	--	--	--
18	" "	"	7	72	--	--	--	.1	--	--	--	1	--	--	--
19	" "	"	9	66	--	--	--	.1	--	--	--	1	--	--	--
20	" "	"	20	84	--	--	--	.3	--	--	--	1	--	--	--
21	OCS-21693 (EC)	1#/gal	5	62	--	--	--	.1	--	--	--	0	--	--	--
22	" "	"	7	72	--	--	--	.3	--	--	--	0	--	--	--
23	" "	"	9	79	--	--	--	.3	--	--	--	0	--	--	--
24	" "	"	20	78	--	--	--	2.8	--	--	--	1	--	--	--
25	ACS-22 (Verm)	5	7.5	74	--	--	--	0	--	--	--	0	--	--	--
26	" "	"	15	70	--	--	--	1.0	--	--	--	1	--	--	--
27	" "	"	22.5	80	--	--	--	1.1	--	--	--	4	--	--	--

Table 1 (Cont'd.):

TRT NO	CHEMICAL AND FORMULATION	% ai	# ai/A	% CRABGRASS CONTROL (SEPT) TEST 1	2 THATCH	3 THIN	MAX TURF INJURY* (APRIL TO SEPT) TEST 1	2 THATCH	3 THIN	% BARE (SEPT) TEST 1	2 THATCH	3 THIN
28	ACS-22 (Verm)	5	40	97	--	--	2.7	--	--	19	--	--
29	ACS-22 (EC)	2#/gal	7.5	44	--	--	.5	--	--	0	--	--
30	" "	"	15	45	--	--	1.9	--	--	5	--	--
31	" "	"	22.5	55	--	--	2.5	--	--	7	--	--
32	" "	"	40	87	--	--	3.2	--	--	9	--	--
33	Azak (Verm)	5	10	92	89	99	.1	.1	.7	2	.3	0
34	" "	"	15	99	--	100	.1	--	.5	1	--	0
35	" "	"	20	100	--	99	.2	--	.3	3	--	0
36	Azak (WP)	80	10	99	--	99	.1	--	.1	1	--	0
37	" "	"	15	100	--	99	.5	--	.3	2	--	2
38	" "	"	20	100	--	100	.2	--	.5	5	--	2
39	Betasan (EC)	4#/gal	5	90	--	--	.1	--	--	1	--	--
40	" "	"	10	99	--	--	0	--	--	1	--	--
41	" "	"	15	100	--	--	.1	--	--	1	--	--
42	Betasan (cob)	7	5	83	--	--	0	--	--	0	--	--
43	" "	"	7.5	84	--	--	.1	--	--	1	--	--
44	" "	"	10	99	--	--	.3	--	--	5	--	--
45	" "	"	12.5	99	--	--	0	--	--	1	--	--
46	" "	"	15	99	89	92	.2	.2	0	2	.5	0
47	" "	"	30	99	--	--	.1	--	--	2	--	--
48	Pre-San (liq)	4#/gal	10	99	--	--	.1	--	--	1	--	--
49	" "	"	15	99	--	--	.1	--	--	1	--	--
50	Trifluralin (Fert)	.34	1.5	76	--	--	.6	--	--	0	--	--
51	" "	"	3.0	99	--	--	.8	--	--	0	--	--
52	" "	"	4.5	99	--	--	1.7	--	--	3	--	--
53	Trifluralin (Verm)	.86	1.5	88	--	96	1.2	--	.8	1.5	3	--
54	" "	"	3.0	99	--	--	2.0	--	--	4	--	--
55	" "	"	4.5	97	--	--	2.9	--	--	10	--	--
56	Trifluralin (EC)	4#/gal	1.5	64	--	--	.9	--	--	1	--	--
57	EL-110 (Fert)	.46	2	81	--	--	.1	--	--	2	--	--
58	" "	"	4	99	--	--	.1	--	--	1	--	--

Table 1 (Cont'd.):

TRT NO	CHEMICAL AND FORMULATION	% ai	# ai/A	% CRABGRASS CONTROL (SEPT) TEST 1	2 THATCH	3 THIN	MAX TURF INJURY* (APRIL TO SEPT) TEST 1	2 THATCH	3 THIN	% BARE (SEPT) TEST 1	2 THATCH	3 THIN
59	EL-110 (Fert)	.46	6	100	--	--	--	.7	--	--	--	1	--	--	--
60	EL-110 (Verm)	1.15	2	43	--	81	78	.5	--	.6	.7	0	--	0	0
61	" "	"	4	83	--	--	--	1.3	--	--	--	2	--	--	--
62	" "	"	6	91	--	--	--	2.2	--	--	--	2	--	--	--
63	EL-110 (EC)	2#/gal	2	59	--	--	--	.6	--	--	--	1	--	--	--
64	Trifluralin + Diphenatrile	.11 + 3.44	.5 + 15	93	--	--	--	.1	--	--	--	0	--	--	--
65	Diphenatrile (Verm)	11.5	30	37	--	--	--	0	--	--	--	0	--	--	--
67	Tupersan (Verm)	4.04	4.5	53	--	--	--	.5	--	--	--	1	--	--	--
68	" "	"	9	94	93	95	99	0	.1	.1	0	0	0	0	0
69	" "	"	18	88	--	--	--	.3	--	--	--	1	--	--	--
70	" "	"	36	99	--	--	--	.1	--	--	--	2	--	--	--
71	Tupersan (Fert)	2.34	9	93	--	--	--	0	--	--	--	1	--	--	--
72	" "	"	18	96	--	--	--	0	--	--	--	0	--	--	--
73	Tupersan (WP)	50	9	87	--	--	--	.1	--	--	--	0	--	--	--
74	" "	"	18	100	--	--	--	0	--	--	--	1	--	--	--
75	TOK-2 (clay)**	2	8	59	--	--	--	3.3	--	--	--	18	--	--	--
76	" "	"	16	61	--	--	--	4.9	--	--	--	73	--	--	--
	" "	"	10	--	--	57	67	--	--	3.5	3.8	--	--	12	17
77	UC 22463 (clay)**	5	6	59	--	--	--	.9	--	--	--	0	--	--	--
78	" "	"	8	77	--	46	74	1.5	--	3.3	.5	1	--	3	0
79	" "	"	10	92	--	--	--	1.9	--	--	--	1	--	--	--
80	" "	"	12	73	--	--	--	1.7	--	--	--	1	--	--	--
81	EH-9180 (clay)	5	15	14	--	--	--	.3	--	--	--	0	--	--	--
82	" "	"	25	0	--	--	--	.9	--	--	--	0	--	--	--
83	EH-52445 (clay)	2	3	0	--	--	--	2.5	--	--	--	3	--	--	--
84	" "	"	6	7	--	--	--	3.5	--	--	--	7	--	--	--
85	64-125 (Liq)	3/4#/gal	30	7	--	68	0	1.2	--	.5	2.3	3	--	0	0
86	" "	"	50	17	--	--	--	1.4	--	--	--	2	--	--	--
87	" "	"	70	23	--	--	--	2.0	--	--	--	8	--	--	--
88	MH-30 (Liq) x	3#/gal	4	0	--	--	--	.3	--	--	--	0	--	--	--

Table 1 (Cont'd.):

TRT NO	CHEMICAL AND FORMULATION	% ai	# ai/A	% CRABGRASS CONTROL (SEPT) TEST 1	2 THATCH	3 THIN	MAX TURF INJURY* (APRIL TO SEPT) TEST 1	2 THATCH	3 THIN	% BARE (SEPT) TEST 1	2 THATCH	3 THIN
89	MH-30 + Azak (WP) x	--	4+15	99	--	--	1.3	--	--	2	--	--
90	MH-30 + Bandane (EC) x	--	4+35	27	--	--	.3	--	--	1	--	--
66	MH-30 + Betasan (EC) x	--	4+15	98	--	--	2.2	--	--	4	--	--
91	MH-30 + Betasan (EC)	--	4+15	99	--	--	.3	--	--	2	--	--
92	MH-30 + DCPA (WP) x	--	4+10	99	--	--	1.6	--	--	6	--	--
93	MH-30 + DMPA (Liq) x	--	4+25	99	--	--	2.0	--	--	7	--	--
94	MH-30 + Trifluralin (EC) x	--	4+1.5	40	--	--	1.4	--	--	3	--	--
102	MH-30 + Tupersan(EC) x	--	4+ 9	90	--	--	1.3	--	--	1	--	--
96	Bandane (gran)	set 10	35	96	--	--	.1	--	--	1	--	--
97	H-9573 (gran)	set 8	15	99	--	--	0	--	--	0	--	--
98	R-4461 (gran)	set 8	15	100	--	--	0	--	--	0	--	--
100	Fert	10-6-4	40N	16	--	--	0	--	--	0	--	--
101	"	10-6-4	80N	10	--	--	0	--	--	0	--	--
103-108	Checks			0	0	0	.1	0	.3	.2	0	0
	LSD 5%			24	8	10						
	LSD 1%			31	10	14						
	Average crabgrass in checks			45%	92%	46%						

*Injury rating--0 = none, 5 = 100% killed
**Misformulation, see appendix
x 50 gal/A

COMBINATIONS OF PREEMERGENT CRABGRASS HERBICIDES AND MALEIC HYDRAZIDE FOR GRASS CONTROL ON MEDIAN STRIPS AND HIGHWAY SHOULDERS[1]

J. A. Jagschitz, R. C. Wakefield and R. S. Bell[2]

The use of maleic hydrazide (MH-30) to retard the growth of grasses along highways is now a fairly common practice. To be most effective, MH-30 should be applied by very early May. Normally, crabgrass germinates after this time so is unaffected by the maleic hydrazide.

Skogley and Jagschitz (1) demonstrated in 1963 that dry formulations of diphenatrile + trifluralin, Dacthal, Zytron, Betasan, Bandane and diphenatrile gave 84 to 94 percent crabgrass control.

The 1964 experiment reported here was designed to obtain information on the usefulness of liquid preemergent crabgrass herbicides alone and in combination with maleic hydrazide. The effects on the growth of the permanent grasses was also noted, since economy of maintenance is achieved by reducing the number of mowings per season.

Procedure

Sections of median strips and the west shoulder of U.S. Route 1 in South Kingstown, R.I. were made available by the State Department of Public Works[3]. The median strip was mowed prior to treatment which evened the turf height, but the shoulders were not. The predominant grasses were red and tall fescues. Fifteen chemical treatments as shown in Table 1 were applied on May 6 and 7 with a highway truck unit especially designed by the Naugatuck Chemical Company[4] for high-speed, even applications. The treatments were applied at 50 gallons to the acre. The treatments were completely randomized in each of three blocks, both on the median and shoulder areas. The individual plots were 15'x90'.

During the season observations were made to determine if the treatments caused any discoloration to the permanent grasses. Dry weight of clippings from a 2'x50' strip in each plot was obtained on May 27 and June 17. A different strip was used on the latter date so this yield does not indicate

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[3]Mr. John Griffith, State Landscape Architect, helped in the selection and the supervision of the experimental areas.

[4]Mr. P. W. Bohne supervised the applications of herbicides.

regrowth. Height measurements of creeping red fescue and tall fescue were made on June 3 and 19.

The 1964 season was unusually dry so that most crabgrass germination was delayed until late summer. Counts of crabgrass plants were made in October on 10 randomized one-square-foot areas in each plot of the median strip. No counts of crabgrass were made on the shoulder because of great variability. Percent crabgrass control was based on the reduction when compared to the untreated plots.

Results and Discussion

Median strips

The data in Table 1 show that MH-30 (maleic hydrazide) markedly reduced the growth of grasses as measured by clipping weight. MH-30 reduced the weight of grass when applied alone or when combined with each of the seven preemergent crabgrass herbicides. The average clipping weight for the seven crabgrass herbicides was 4.8 and 7.1 pounds in May and June but when combined with MH-30 the weight was 1.8 and 2.1. Clipping weights from plots treated with MH-30 combined with each of the crabgrass herbicides were not significantly different from one another. Weights obtained from the herbicide treatments alone in May were not significantly different from the check weight. In June Azak and Zytron treated plots yielded significantly less than the check, but still significantly more than the MH-30 treated plots.

The height of creeping red fescue and tall fescue is presented in Table 2. Treatments with MH-30 reduced the height of both fescues. Plots not treated with MH-30 alone or in combination with the crabgrass herbicides had grass 2½ to 3 times as tall as those grasses in plots receiving MH-30.

No flower heads developed on the grasses treated with MH-30 while those without this growth regulant bloomed profusely. The entire experimental area was mowed to a height of 3 inches before July 4. On August 21 creeping red fescue ranged from 3-5 inches and tall fescue 3-7 inches. No particular differences in height were detected at this time so the whole area was mowed again before September 1. The overall appearance of the median strips was degraded by flower stalks of various dicotyledonous weeds which were not inhibited by any of the chemical treatments. Hawkweeds and several "dandelion-like" weeds predominated in the turf of the median strips. These plants produce a basal rosette of leaves. The flower stalks give a stemmy appearance to the turf.

Percent crabgrass control from the various treatments are presented in Table 3. Azak, Betasan, Dacthal and Tupersan, with and without maleic hydrazide, and Zytron and trifluralin with maleic hydrazide gave effective control of crabgrass. Maleic hydrazide alone produced no crabgrass control but the effectiveness of Zytron and trifluralin were better in this test when combined with MH-30. The crabgrass control with Bandane with and without maleic hydrazide and Zytron alone was unsatisfactory.

Table 1. Effect of maleic hydrazide and preemergent crabgrass herbicides on dry weight of highway grasses (URI & DPW 1964).

Tmt No	Herbicide	lb ai/A	Dry weight of clippings (lb per 1000 sq ft) Median 5/27	Median 6/17	Shoulder 5/27	Shoulder 6/17
1	MH-30	4	1.4	1.2	11.4	12.7
2	Azak WP	15	3.1	4.9	14.0	11.8
3	Bandane EC	35	3.0	5.3	5.8	11.8
4	Betasan EC	15	6.8	8.6	4.1	14.2
5	Dacthal WP	10	6.1	8.0	15.7	19.4
6	Zytron liq	15	3.8	4.9	12.7	14.6
7	Trifluralin EC	2	3.9	5.9	11.4	17.7
8	Tupersan WP	10	6.7	12.4	7.1	11.0
9	MH-30 + Azak	4 + 15	2.0	2.8	6.4	6.4
10	MH-30 + Bandane	4 + 35	2.0	2.3	5.2	6.2
11	MH-30 + Betasan	4 + 15	3.5	2.5	5.1	4.9
12	MH-30 + Dacthal	4 + 10	1.3	1.6	5.4	8.2
13	MH-30 + Zytron	4 + 15	1.7	2.5	4.3	8.6
14	MH-30 + Trifluralin	4 + 2	0.9	1.2	-	- *
15	MH-30 + Tupersan	4 + 10	2.3	1.6	7.8	10.2
16	Check	-	5.1	8.3	10.5	18.8
	LSD 5%		3.0	3.3	NS	NS
	LSD 1%		4.0	4.4	NS	NS
	Average crabgrass herbicides		4.8	7.1	10.3	14.2
	Average as above plus MH-30		1.8	2.1	4.9	6.4

* Insufficient trifluralin for shoulder treatments.

Table 2. Effect of preemergent crabgrass herbicides and maleic hydrazide on height of fescues (URI & DPW 1964).

Tmt No	Herbicide	lb ai/A	Height of grass in inches: Creeping red fescue, Median 6/3	Creeping red fescue, Median 6/19	Creeping red fescue, Shoulder 6/3	Creeping red fescue, Shoulder 6/19	Tall fescue, Median 6/3	Tall fescue, Median 6/19	Tall fescue, Shoulder 6/3	Tall fescue, Shoulder 6/19
1	MH-30	4	4	4	6	7	6	6	9	10
2	Azak WP	15	12	17	14	17	18	22	22	27
3	Bandane EC	35	13	18	13	18	19	24	19	26
4	Betasan EC	15	13	18	10	15	19	24	19	24
5	Dacthal WP	10	14	17	14	18	19	25	21	27
6	Zytron liq	15	11	14	11	17	18	21	21	24
7	Trifluralin EC	2	14	19	13	19	21	26	21	24
8	Tupersan WP	10	13	18	12	17	20	24	20	26
9	MH-30 + Azak	4 + 15	5	5	6	6	7	7	8	8
10	" + Bandane	4 + 35	5	5	6	6	6	6	9	8
11	" + Betasan	4 + 15	4	4	6	6	6	6	8	8
12	" + Dacthal	4 + 10	5	5	6	6	6	7	8	8
13	" + Zytron	4 + 15	4	5	6	6	6	7	9	8
14	" + Trifluralin	4 + 2	4	4	-	- *	6	4	-	- *
15	" + Tupersan	4 + 10	5	5	7	7	7	7	10	8
16	Check	-	13	18	13	17	19	24	20	24
	LSD 5%		2	2	2	2	3	3	3	3
	LSD 1%		3	3	3	3	5	5	4	4
	Average crabgrass herbicides		13	17	13	17	19	24	20	25
	Average as above + MH-30		5	5	6	6	6	6	9	8

* Insufficient trifluralin for shoulder treatments.

Table 3. Effect of maleic hydrazide and preemergent herbicides on the control of crabgrass plants in median strip (URI & DPW 1964).

Tmt No	Herbicide	lb ai/A	Percent crabgrass control *
1	MH-30	4	0
2	Azak WP	15	97
9	Azak WP + MH-30	15+4	98
3	Bandane EC	35	26 **
10	Bandane EC + MH-30	35+4	13 **
4	Betasan EC	15	96 **
11	Betasan EC + MH-30	15+4	84 **
5	Dacthal WP	10	99
12	Dacthal WP + MH-30	10+4	99
6	Zytron liq	15	31 **
13	Zytron liq + MH-30	15+4	83 **
7	Trifluralin EC	2	66
14	Trifluralin EC + MH-30	2+4	89
8	Tupersan WP	10	97
15	Tupersan WP + MH-30	10+4	96
16	Check	-	0
	LSD 5%		28
	LSD 1%		38

* Average number of crabgrass plants in check plots was 69 per square foot.

** Some turf discoloration.

Zytron, alone and with MH-30, produced moderate turf discoloration within a week. The grass tips, especially of creeping red fescue, were purplish-brown. A slight to moderate yellowing of the turf, particularly on tall fescue, was produced by Bandane, alone and with MH-30. In five out of twelve of the Betasan plots, tall fescue was slightly yellowed. The use of low gallonage is felt to contribute to the degree of discoloration caused by these herbicides.

Shoulders

Maleic hydrazide apparently reduced the dry weights of clippings from the shoulders (Table 1). The average dry weight for the May and June harvest was 4.9 and 6.4 pounds with maleic hydrazide and 10.3 and 14.2 pounds without it. Unfortunately the soil on the shoulders and the distribution of tall fescue was more variable than on the median strip. Not mowing the shoulders to a uniform height before treatment contributed to the variability. This variability probably caused the lack of significance.

The heights of red fescue and tall fescue were significantly lower where MH-30 was applied (Table 2). Variations in height of grass among the herbicides themselves were of minor importance.

Summary and Conclusions

Maleic hydrazide alone and in combination with various preemergent crabgrass herbicides was applied to highway median strips and shoulders during the first week of May 1964. The summer was unusually dry so crabgrass germination was mostly delayed until late August.

The dry weights and heights of grasses in the median strip were significantly reduced where maleic hydrazide was included in the treatment.

On the shoulders, weight differences were not significantly different due to variations in the soil, plant populations, and uneven grass height before treatment. The heights of red fescue and tall fescue were lower where MH-30 was applied.

Bandane, Betasan and Zytron, with and without maleic hydrazide, caused some turf discoloration. Azak, Betasan, Dacthal and Tupersan, with and without maleic hydrazide, produced good control of crabgrass in the median strip. Zytron and trifluralin, with MH-30, also produced good crabgrass control. Bandane emulsion under the condition of this experiment did not perform satisfactorily.

Reference Cited

1. Skogley, C. R. and J. A. Jagschitz. 1964. Preemergence control of crabgrass with fall or spring herbicide applications. NEWCC 18: supplement, pp. 87-94.

Appendix

Names and sources of the herbicides are as follows: Azak = 2,6-di-tert-butyl-p-tolyl-methylcarbamate (Hercules); Bandane = Polychlorodicyclopentadiene isomers (Velsicol); Betasan = N-(beta-O,O-diisopropyl-dithiophosphorylethyl)-benzene sulfonamide (Stauffer); Dacthal (DCPA) = dimethyl 2,3,5,6-tetrachloroterephthalate (Diamond Alkali); MH-30 (maleic hydrazide) = 1,2-dihydropyridazine-3,6-dione (U.S. Rubber); Trifluralin = a,a,a-trifluoro-2,6-dinitro-N,N dipropyl-p-toluidine (Elanco); Tupersan = 1-(2-methylcyclohexyl)-3-phenylurea (DuPont) and Zytron (DMPA) = O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate (Dow).

EXCRETION OF FOLIARLY-APPLIED DICAMBA AND PICLORAM FROM ROOTS OF BLACK VALENTINE BEANS GROWN IN SOIL, SAND, AND CULTURE SOLUTION

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Abstract

The excretion of foliarly-applied dicamba (2-methoxy-3,6-dichlorobenzoic acid) and picloram (4-amino-3,5,6-trichloropicolinic acid) from roots of Black Valentine beans (*Phaseolus vulgaris* L.) were studied. All experiments were conducted in walk-in type growth chambers under the following environmental conditions, measured at plant height: 1600 ± 100 ft-c (16 hr day, 8 hr night), 23 ± 1°C, and 50 ± 5% relative humidity.

Dicamba and picloram were released from roots in detectable amounts, apparently unchanged, following several methods of application. The herbicides were reabsorbed by untreated control plants, growing in the same container, which exhibited characteristic growth-regulator symptoms within 3 days. Volatility was not responsible for the symptoms observed on the control plants under these conditions.

Transfer was demonstrated through soil, sand, and several liquid culture media ranging from distilled water to full strength nutrient solution. Extremely small dosages of herbicide (ca. 2 ug/plant) were required to demonstrate the phenomenon. Although picloram is somewhat more potent than dicamba on a molar basis, both compounds were transferable with about equal facility.

The findings were tentatively confirmed by paper chromatography and several bioassay procedures.

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