THE USE OF VEGETATIVE CHARACTERISTICS IN GRASS IDENTIFICATION

by C. E. Phillips [1/]

For many people the identification of grasses has long been a problem. The standard method based on the flowering parts (inflorescence) of the plant involves such minute differences that it is very easy to go astray. There is also the problem of those people working with pastures and lawns where, under normal conditions, most grasses do not produce flowering parts. Now, of course, we have chemical weed control and are faced with the fact that, to be effective, herbicides must be applied long before the flowering parts appear. The use of vegetative keys for grass identification in this country goes back almost half a century. There are several good keys available but they are quite regional in their coverage and do not include all the principal cultivated and weed grasses of the Northeast. For this reason and also because the vegetative characters used in the keys are both quite small and unfamiliar, it is doubtful if there are more than a few persons in the region who even attempt their use. Up to this time most of those concerned with chemical weed control have perhaps not felt that it was necessary to go beyond the point of identifying a weed as a grass. It is certain however that the time is fast approaching when both research and service personnel must be able to identify grasses by genus and species. Some of the newer herbicides have already given an indication that they can be specific for certain grasses. Just recently I saw where one of the newer chemicals had been sprayed in a test strip across sixteen different grasses. Fourteen had been killed outright or very severely damaged. Two were apparently unaffected. Let us just make comparisons between very closely related grasses. Common Kentucky bluegrass was killed but Merion showed only a faint discoloration. Meadow fescue was killed but Ky. 31 fescue was apparently not affected. While it may be quite difficult to take a sample and say with certainty whether it is common or Merion Kentucky bluegrass, meadow fescue and Ky. 31 can be readily identified by their vegetative characteristics if, and this is a big "if", you know what to look for.

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Now let us take a look at the vegetative characteristics that are most useful in grass identification. But first let me say that a magnifier is just as essential in grass identification as eyes. Personally I prefer a triplet with a range of 5 to 20-X. The 10-X combination is best for general use but I like the 20-X for checking very small details. Another very useful tool is a Pocket comparator. This instrument has 6-X magnification with a measuring scale graduated to .2 mm. The starting point for most vegetative keys is the position of the blade in the bud-shoot. All grasses are either rolled or folded. But sometimes the rolled bud-shoot may be decidedly flattened and appear to be folded. A grass is never classified as folded in the bud-shoot unless the blade is folded just once in the middle. For grasses with blades under 3 mm. wide it is almost impossible to determine with certainty whether it is rolled or folded.

The blade itself may be smooth, rough or hairy on the top surface and on the lower surface. Roughness is determined by "feel" preferably using a more sensitive area of the skin than the finger tips. Very short hairs can only be detected by careful examination with a magnifier. In some grasses the midrib is prominent below, that is raised above the surface. The blade margin (edge) may be smooth, rough or hairy. The best way to determine this is to view with a magnifier the edge of the blade silhouetted against a light or the sky.

The next most prominent part of the grass leaf is the lower part that encloses the stem -- the sheath. In some grasses, notably the bromes, the sheath is a closed tube to near the top. In most grasses, however, the sheath is split from the top to the point of attachment and is overlapping at least at the base. The margins of this split sheath most generally are hyaline, that is thin and translucent and whitish in appearance. However, in some grasses one margin is hyaline and the other is hairy and in others both margins are hairy. Of coarse, whether split or closed, the sheath may be smooth, rough or hairy. The shape of the sheath in cross-section may vary from distinctly flattened or compressed to round. At times we find that in a grass with a round sheath the blade midrib apparently continues prominently on down into the sheath as a ridge and we refer to the sheath as being keeled.

All grass leaves are attached to the stem at a point called the node. In most grasses the node is smooth and without hairs.

In a few grasses with smooth sheaths we find a ring of hairs at the node. In at least one other with a very hairy sheath we find a narrow, sticky ring just below the node that is completely without hairs.

Moving now to the area where the blade is attached to the sheath, we find in many grasses claw-like projections extending from the base of the blade and more or less wrapping around the stem or emerging bud-shoot. The projections are called auricles and they may be quite small and slender or rather large and prominent. In a few grasses careful examination of the auricles with a magnifier will reveal that they are hairy.

At the base of the blade or the top of the sheath and behind the stem or emerging shoot we nearly always find a projection called the ligule. I say "nearly always" because it is absent in the genus that includes barnyard grass and Japanese millet. Ligules are of two types, a thin whitish membrane or a fringe of hairs, and may vary in length from .2 mm. or less to 8.0 mm. or more. The membranous ligules may vary in shape from those that are flattened across the top or truncate, to those that generally have a decided notch on one or both sides or in the center, or to those that rise to a sharp acute or acuminate point in the center. The margins of most of these membranes are entire or without divisions, lobes or teeth. However some of them have a saw-toothed edge and in some the edge or margin ends in fine hairs and is said to be ciliate. In a few grasses we find that the back of this membrane is covered with very fine hairs. The ligules that are a fringe of hairs have less variations than the membranous ones. In some grasses we find that the ligule is made up of a fringe of short hairs with some scattered hairs that are very much longer. These long hairs may be across the entire width of the ligule or just on the sides. In other grasses we find that the hairs are fused together at the base so that the lower part appears to be membranous. In these cases the question could be raised as to the dividing line between a ligule that is a fringe of hairs fused at the base and a membranous ligule that is ciliate. My division is this -- if the fused or membranous portion is shorter than the hairs, it is called a fringe of hairs fused at base; if the fringe of hairs is shorter than the membrane, it is a membranous ligule that is ciliate.

Within this coming year a key for the identification of the important grasses of the Northeast by their vegetative characteristics will be available. This key will be simplified as much as possible but of necessity many of the separations will be based on differences as seen through a 10-X magnifier. I trust that these magnified color transparencies you have just seen will help you "see" what you "look at" and successfully use the key.

FACTORS INFLUENCING THE PERFORMANCE OF GRANULAR HERBICIDES

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Summary

In the last year or two numerous investigators have studied dry granular carriers for herbicides. Previous to this only a few had seriously investigated their possibilities.

Amongst farmers, the interest in granulars stems primarily from their dislike for hauling water or for running the sprayer to some location away from the field in order to refill. The water problem is acute even in regions where water is relatively plentiful.

Of considerable concern to weed workers is the performance of granular formulations as compared to that of the conventional formulations. Research to date on performance is wholly inadequate to permit many conclusions or generalizations. Some of the factors influencing performance are as follows:

1. The chemical itself has an important bearing on results. Certain compounds such as EPTC almost always give better results on a granule. On the other hand Atrazine at lower rates performs better as a wettable powder. CDEC may perform better or worse on a granule depending on factors at present unknown.

2. The nature of the carrier may play an important role, but little is known regarding the several types of carriers, particle size, percentage on the carrier, best method of formulating, etc.

3. The influence of environment and soil on granular formulation as compared to conventional formulation, is sufficiently well understood.

4. Even distribution of the herbicide at the desired rate is as necessary with granulars as with liquids. Presently available equipment does not lend itself to easy, accurate application. However, equipment manufacturers are aware of the needs, and presumably in the near future will have machines available to do the job well.

THE METABOLISM OF CERTAIN HERBICIDES BY PLANTS--A FACTOR IN THEIR BIOLOGICAL ACTIVITY[1,2,4]

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Since ancient times, man has sought chemicals to abate disease, the disease of his livestock and to control pests that exact their toll of his food crops. The rise of exact scientific studies in chemistry and biology permitted man to turn his attention to the effect of these chemicals on the organism exposed to them. It was early noted in animal experiments that the animals were able to tolerate a prolonged exposure to low concentrations of many of the organic chemicals tested. In attempting to discover the reason for this tolerance, it was found that the animals were able to detoxify or metabolize these drugs (4). The metabolism was found to take many forms in animals ranging all the way from the formation of a simple conjugate to a complete metabolism of the administered drug. It was found that the compound administered might be conjugated to simple amino acids, sugars or proteins, it may be coupled with sulfur-containing amino acids to form the mercapturic acids, the compound might be hydroxylated, via oxidation or the compound might be oxidized completely to carbon dioxide and water (4). Very often a combination of these detoxification mechanisms were found. Subsequently, it was shown that microorganisms, insects and other lower animals possess the same ability to metabolize organic substances. It is now known that microorganisms particularly have a wide range of abilities to deal with organic materials introduced into their environment.

Although it may have been surmised that plants possess the same ability to metabolize drugs, it remained for the workers at Boyce Thompson Institute (15,16, 17) to demonstrate this phenomena. These workers studying the effects of various fumigants on plants discovered that ethylene chlorohydrin was rapidly converted to a glycoside. Subsequently, other compounds were shown to be metabolized by plants, such as the dinitrophenols, where it was demonstrated that plants possess the ability to reduce one of the nitro groups of the dinitrophenol.

The introduction of growth-regulating compounds for weed control and for horticultural purposes greatly stimulated interest in the metabolism of chemicals by plants. The theory has been advanced that the mode of action of certain of these compounds may depend upon the metabolic conversion to an active form (14, 18). That such may be the case in certain instances was demonstrated by the workers at Boyce Thompson Institute who showed in 1947 that the omega phenoxy alkyl carboxylic acids could be converted by beta oxidation to 2,4-D (21). There remained for Wain (22) and his colleagues (2) in England, however, to make practical application of this discovery.

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The introduction of synthetic organic compounds such as 2,4-D for practical application in agriculture led to a renewed interest in determining the mode of action of the natural occurring plant hormones. A good deal of attention was focused on indole-3-acetic acid (IAA) resulting in the discovery of its destruction in the plant by the indoleacetic acid oxidase (2). It was demonstrated that the IAA was destroyed by oxidation which fact was thought to be related to the manner in which the chemical induced certain plant responses. It was felt that since the indoleacetic acid oxidase was a riboflavin-containing material, that this system would be light sensitive and hence on unilateral illumination of a plant stem, a greater amount of the indoleacetic acid would be destroyed on the lighted side. With destruction of the IAA, a loss of stimulation of cellular activity would be suffered with greater growth occurring on the dark side causing a bending of the stem. In addition to undergoing oxidation, it was found that IAA may also be conjugated to amino acids and proteins of the plant. Andreae (1) has been able to isolate free indoleacetyl aspartic acid from plants exposed to IAA.

It was only natural that considerable attention should be devoted to the mode of action of 2,4-D. In the course of such studies, it was found that this compound underwent modification after absorption by the plant. This modification could clearly be demonstrated to be the result of the action of various metabolic activities by the plant. For example, Holley and his co-workers (11,12) found a new derivative of 2,4-D following administration to a plant which he indicates is a hydroxylated form of the parent compound. Additional metabolism of 2,4-D by the plant was demonstrated by Jaworski (13) in finding that 2,4-D is conjugated to peptides. These conjugates were found to be biologically inactive when isolated and then applied to a plant. More complete breakdown of 2,4-D by the plant's metabolism is illustrated in the findings of Weintraub, et al. (24,25) and Butts and Fang (3,5) that $C^{14}O_2$ was evolved from a plant treated with C^{14} labeled 2,4-D. The rate of evolution of $C^{14}O_2$ varied between the carboxyl and methylene labeled 2,4-D with the greatest evolution occurring in the carboxyl labeled material. While the exact mechanism of the oxidation is not clearly understood, it may be a riboflavin requiring enzyme is involved as has been shown in the case of microorganisms (2). In this instance, metabolism results in cleavage of the ether bond between the ring and side chain giving rise to the corresponding phenol.

Subsequently, it was found that other herbicides are metabolized by plants. For example, monuron had been demonstrated to conjugate in the plant (7). The more recently discovered triazines have been demonstrated by Roth (18) to undergo metabolism in the plant. The U. S. D. A. workers have shown also that 2,2-dichloroprepionic acid may enter the plant metabolic system, competing with β alanine (20).

This laboratory has been interested for a number of years in the metabolism of herbicides by plants. This interest stems in part from studies on the mode of action of these compounds and in part from the relationship of this important phenomena to chemical residue problems. Clearly if the compound is being destroyed by the plant, the amount of chemical remaining to serve as a residue is markedly lessened. It has been found that the plant may utilize several metabolic pathways for detoxifying these chemicals. The experimental results will be presented according to the type of metabolism suffered by the compound.

1. <u>Conjugation</u>.

As pointed out earlier, Jaworski (13) working at Oregon State College, discovered that 2,4-D was conjugated to a peptide by plants. Several different conjugates were found and the amount of the 2,4-D being conjugated into one or more of these materials varied with the species of plants. The more tolerant grass plants produced so called "unknown 3" conjugate in substantial quantity (3).

Another compound found to undergo conjugation was monuron. Like 2,4-D, this material was conjugated to a peptide or a low molecular weight protein. In this instance the C^{14} labeled material was applied to the plant and at varying intervals subsequent to this the plant harvested, sectioned and the radioactivity extracted. This radioactivity was then fractionated by paper chromatography and an attempt made to determine the nature of the radioactive spot on paper (7). Table 1 shows the changes in the concentration of various radioactive components of the plant extract.

Table 1*

Distribution of Major Radioactive Compounds in 80% Ethyl Alcohol Extract of Bean Leaves

(After treatment with 50 γ of carbonyl-C^{14}-labeled CMU. Plants harvested after varying intervals.)

Harvested, Days after treatment	R_f 0.62-0.66, CMU Complex, %	R_f 0.84-0.87, Free CMU, %
1 hour	0	100
1	5	93
2	11	87
4	13	85
8	19	80
12	19	81

2. Hydrolysis.

The hydrolytic enzymes of plants are fully capable of hydrolytic cleavage of bonds in herbicides. Hagen et.al. (10) early demonstrated the ability of plant lipase to hydrolyze the ester of 2,4-D. Recently very good evidence has been brought forth to show that the various esters of 2,4-D are rapidly hydrolyzed in the plant and that the active compound is, therefore, 2,4-D acid. It would be expected similarly, that other ester-type compounds such as the carbamates might probably undergo hydrolysis in the plant. Such is the case with EPTC which we have recently been able to show does undergo hydrolysis according to the following reaction:

$$(C_3H_7)_2N-\overset{\overset{O}{\|}}{C}-S\,C_2H_5 + H_2O \xrightarrow{\text{Enzymes}} (C_3H_7)_2NH + C_2H_5SH + CO_2$$

*From Fang, Freed, et.al., J. Ag. Food Chem., 3, 400, 1955.

The components of the foregoing reaction may further be metabolized as is shown by the distribution of S^{35} of S^{35} EPTC, Fang and Theisen (6).

3. Oxidation.

Of particular interest is the ability of plants to metabolize herbicides via oxidation. By this means the compound may be radically altered or completely destroyed by the plants metabolism. In view of the complexity of the plants enzyme system it is not surprising to find that they possess the ability to oxidize herbicides nor is it startling to find that the carbon dioxide arising from this oxidation is further incorporated into plant constituents.

One of the first compounds coming under investigation was endothal. This compound is an effective pre-emergence herbicide for the chenopod crops such as sugar beets and spinach. Their tolerance for this compound is well known and it was thought possible that these plants might possess the ability to metabolize the material giving rise at least in part to the observed tolerance. Accordingly experiments were undertaken using C^{14}- labeled endothal to determine precisely the nature of this relationship.

Beets were seeded in soil and a pre-emergence application of radioendothal made to the soil. The plants after emergence were harvested at intervals and the amount of radioactivity in the plant determined. It was discovered that an appreciable amount of radioactivity could be detected in the plant.

It was not known from the measurement of total radioactivity in the plant whether or not this existed in the form of the parent radioendothal or whether it represented products arising from metabolic attack by either the plant or microorganisms of the soils. Accordingly attempts were made to fractionate the radioactivity by solvent extraction. This was accomplished by taking dried plant tissue and solvent extracting the material, first with ether and then with alcohol. It was demonstrated that the nonpolar solvent, diethyl ether was incapable of extracting endothal whereas the alcohol was an efficient solvent for this purpose. The following table shows a distribution of radioactivity in the different fractions.

Table 2

Crop	% of Total Radioactivity in Ether Extract	Ethanol Extract	Tissue Residue
Beets	6.8	33.5	59.7
Spinach	8.9	29.7	61.4

Table 3
Ion Exchange Chromatography of Alcohol Extracts of Beets and Spinach

	Beets #1 CPM/0.5 ml	Beets #2 CPM/0.5 ml	Spinach CPM/0.5 ml	Radioendothal CPM/0.5 ml
Before column	13.2	13.0	15.6	53.5
After column	14.5	11.6	14.1	0.9

It will be noted that while an appreciable amount of radioactivity exists in fractions, other than that which could be endothal, the significant amount of C^{14} is found in the alcohol extract. In order to learn more about the nature of the compounds containing C^{14} in the alcohol extract, it was decided to attempt to fractionate the radioactivity of this extract using ion exchange columns. The anion exchange columns such as Dowex-1 were found to adsorb endothal quantitatively. Upon passing the radioactive extract through such ion exchange columns, it was found that a considerable quantity of C^{14} passed through the column indicating that it was no longer in the form of endothal. This is shown in Table 3. Chemical tests on the effluent of these columns indicated that the radioactivity was in the form of carbohydrates.

Undoubtedly a considerable amount of the radioendothal was decomposed by soil microorganisms. However, it is felt that the plant itself is exposed to some radioendothal which was probably metabolized by the plant and the radioactive carbon arising from this metabolism incorporated into plant constituents. Of particular importance to us at this juncture is the fact that this study provided us with effective techniques for studies on other compounds.

A compound of rather recent introduction that is showing considerable promise as pre-emergence herbicide is amiben (2,5-dichloro-3-aminobenzoic acid). This material is particularly effective for weed control in soybeans as well as other crops. The stability of the compound suggests that as a matter of necessity the plant must be exposed to the chemical after germination and emergence from the soil. An attempt was made to determine whether or not amiben was oxidized by soybeans. This was accomplished by exposing a soybean plant to a solution of carboxyl C^{14}-labeled amiben in a closed system that permitted the trapping of the CO_2 evolved in sodium hydroxide. This system consists essentially of a train through which air is passed. The train having a wash bottle of sodium hydroxide to remove the carbon dioxide of the air and this CO_2-free air is then passed through the chamber containing the plant with its roots immersed in the nutrient solution containing the labeled chemical. The air is then swept from the chamber to another wash bottle containing sodium hydroxide which traps the CO_2 evolved in the plants respiration. The carbonate produced by the plant and trapped in the sodium hydroxide is then precipitated with barium chloride and plated and counted.

In performing this experiment with carboxyl C^{14}-labeled amiben and soybeans, it was found that a measurable amount of $C^{14}O_2$ was produced. In attempts to localize or to determine which portion of the plant was responsible for production of this radioactive CO_2, the plant was separated into tops and roots and given exposure. By this means it was clearly demonstrated that the oxidation occurred in the roots of the plant.

Another compound of considerable interest is amitrole. This material has proved to be highly effective for the control of many weeds and while active on a wide spectrum of plants, does show a few instances of interesting selectivity between plants. One such case of this selectivity is the surprising tolerance of certain varieties of oats to low levels of application of amitrole. In contrast the other small grains are decidedly sensitive. In the course of studying the amount of amitrole in the different small grain plants, it occurred to us to determine the difference in oxidative pattern between two of the small grains. We early found that the oat plant possessed a marked ability to evolve $C^{14}O_2$ following exposure to carbon 14 labeled amitrole. Figure 1 presents a clear demonstration of the difference in the abilities of the two small grains, oats and barley, to metabolize this compound. The oat plant clearly is able to continue metabolism of the compound whereas the other small grain showing an initial ability to metabolize it rapidly loses this ability perhaps largely through inhibition.

The compound 4(2,4-dichlorophenoxy) butyric acid (2,4-DB) is of particular interest from the standpoint of metabolism. The Boyce Thompson workers had shown that only the phenoxy alkyl acids containing an even number of carbon atom chains group gave rise to an active compound probably through Knoops beta oxidation. Wain and his co-workers (2,22) made brilliant application of this theory and were able to show by means of paper chromatography that 2,4-D did arise in plants exposed to 2,4-DB. The various intermediates that arise through the beta oxidation of phenoxybutyric acids have been isolated from cultures of microorganisms exposed to this chemical (23). However, as yet no one has isolated a system of enzymes from the plant and shown that they are capable of oxidizing this material.

In the course of studies with this compound, it became of interest to us to attempt to prepare a system of enzymes that could be tested for their ability to oxidize 2,4-DB. Accordingly, a number of attempts were made to isolate some such system. It was discovered that an acetone powder preparation from Laxton Progress peas could be used as a source of soluble enzymes that appeared to possess the ability to oxidize this chemical. It was reasoned that since TPN was reduced in the course of fat oxidation, that it should be possible to couple this reduction to a dye and thus enable us to follow the course of the reaction. The tetrazolium compounds are particularly good to couple to such a system since they accept electrons and hydrogen from DPN and TPN, and in so doing form colored compounds. Upon testing this theory, it was found to work admirably.

Utilizing the enzyme system described above with suitable cofactors, it was possible to demonstrate that it used 2,4-DB as a substrate. In fact 2,4-DB proved to be a more satisfactory substrate than did butyrate. The following table presents these findings.

Table 4
The Oxidation of Substrates by Enzyme Preparation from

Chemical	Concentration/Tube	Sample/Std.
2,4-DB	10 γ	1.34
2,4-DB	10 γ	1.66
Butyrate	10 γ	1.10
2,4-D	10 γ	0.45

When the enzyme system was incubated with radioactive 2,4-DB a number of radioactive compounds were produced. This was demonstrated by means of paper chromatography where a time course study demonstrated that the R_f value of the bulk of the radioactivity was changing. In addition, there was a tendency for the radioactivity to become smeared out over the paper indicating the development of a number of radioactive compounds.

The triazine herbicides have been of particular interest in the study of metabolism of herbicides by plants. These recently developed materials (9) have shown some amazing differences in selectivity between plants. The selectivity of simazine and atrazine for corn despite their broad activity against other grasses is especially striking. The tolerance of the corn plant for simazine and atrazine can be accounted for on one of three basis: (a) the compound is not taken up by the corn plant, (b) the enzyme systems of the plant are unaffected by the presence of the chemical, or (c) the plant is able to metabolize the compound to innocuous products. Shortly after the selectivity of simazine and atrazine toward corn was demonstrated, we undertook to study this phenomena using C^{14}-labeled compounds.

The very early experiments clearly indicated, by the presence of C^{14} in the sample, that the plant was capable of taking up readily detectable amounts of simazine and atrazine. Of course it would be argued that the C^{14}-labeled material absorbed by the plant was not simazine or atrazine but something to which they had been converted by soil microorganisms. However, chromatography of soil extracts demonstrated the presence of large quantities of the parent triazine herbicide. Clearly then, at least one of the C^{14}-containing compounds taken up by the corn was the parent triazine.

The question then arose as to whether the C^{14} found in the plant represented the parent herbicide or whether this herbicide had been altered by the plants metabolism. Since it was known that simazine and atrazine could be quantitatively extracted from plant tissue with chloroform samples of the plant tissue were taken at time intervals and exhaustively extracted with chloroform. The following table presents the results of this study.

Table 5
The Percentage of Total C^{14} in Treated Corn which was Chloroform Extractable

	Simazin		Atrazine	
Rate lb/A	Days following treatment	% C^{14} chloroform extractable	Days following treatment	% C^{14} chloroform extractable
2	49	41.0	21	83
8		42.4		89
2	91	33.8	56	75.4
8		39.8		71.2
2	119	18.1	113	72.3
8		28.7		54.9
2	119, ears	53.8	113, ears	48.8
8		39.4		59.6

The fact that there was a change in the percentage of the total radioactivity in the plant extractable with chloroform gave evidence that these compounds were being altered by the plant's metabolism. Clearly it would not be unreasonable to assume that the C^{14} extracted by chloroform would not all necessarily be in the form of the parent triazine. In this instance, the concentration of chemicals in the chloroform is very low so that even compounds normally considered insoluble in this solvent could appear at these low concentrations. An attempt was made, therefore, to further fractionate this radioactivity to determine whether or not a C^{14} in the chloroform represented the parent compound or metabolic products of the parent compound. It was found that the nitrogen of the alkylamino substituent of simazine and atrazine was sufficiently basic so that these compounds could be chromatographed on a cation exchange resin from a chloroform solution. Thus, it was possible to further fractionate the radioactivity by adsorption on Dowex-50. When this was done, it was clearly demonstrated that the C^{14} in the chloroform extract was not all in the form of parent triazine. This is illustrated in the next table.

Table 6

Adsorption of C^{14} of Atrazine or Chloroform Extracts of Plants by Dowex-50 Column.

Solution	Atrazine rate/A	Days following treatment	cpm/0.5 ml Before	cpm/0.5 ml After	% Retained
Atrazine	---	---	374	3.3	99.1
Plant extract	2	119	221.7	6.3	72.2
Plant extract	8	119	207.7	28.1	86.5
Extract of ear	8	119	61.8	32.0	48.2

If the triazine is being degraded by the plant's metabolic activities, the question arises as to how far this degradation is carried. If the degradation is complete, then it would be expected that for radioactivity carbon dioxide should be evolved from the plant. In order to test whether or not this was the case, the closed chamber metabolism experiment as described previously was attempted. In this case, corn plants were germinated in sand and then taken as the test plant. Table 7 clearly demonstrates that the plant is capable of complete degradation of simazine and atrazine.

Table 7

Metabolism of C^{14} Simazin and Atrazine by Corn Plants as Measured by the Release of $C^{14}O_2$

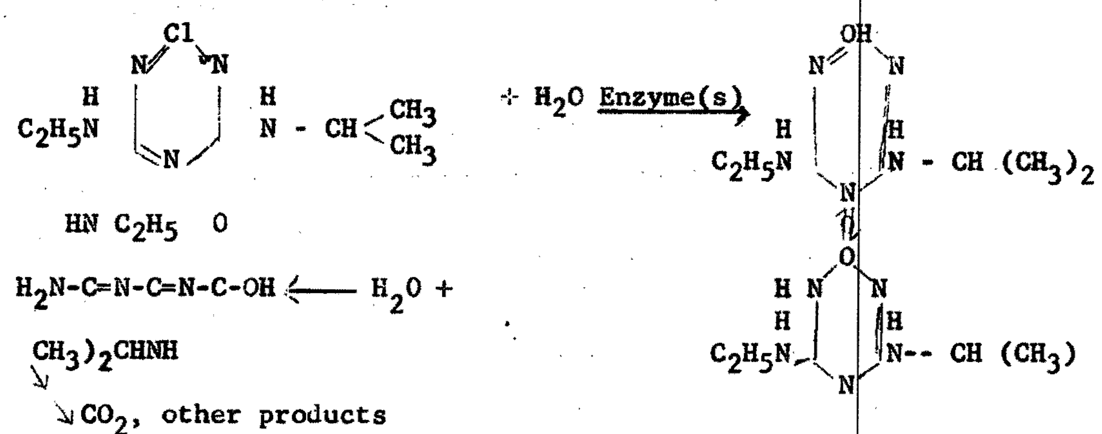
Experiment	Duration hours	µg Triazine metabolized	µg Triazine remaining in plant	% Triazine metabolized of that taken up
Simazine 1	50	.48		
2	48	.19	2.0	8.7
3 (in dark)	68	.91	.53	63.2
Atrazine 1	54	.67	3.05	18.0
2	72	.30	1.49	16.8
3 (in dark)	70	.28	.73	27.7

Since the corn plant is clearly capable of complete oxidation of the triazines as shown above, it now becomes of interest to determine by what mechanism this is accomplished. This was investigated using expressed sap of corn plants to ascertain whether or not the reaction was the result of metabolic activities.

Roth (19) had speculated as a result of his studies on this metabolism that certain polyphenol substances which he found in the sap were the agents responsible for this metabolism. Gysin (8) had suggested from chemical considerations that the first product of metabolism would most likely be the hydroxy triazine. To investigate this possibility, the expressed sap of corn buffered to an appropriate pH was used to incubate with the solution of atrazine. One sample of the juice was boiled to destroy any enzymes that might be present; the other was used fresh. After an appropriate incubation period, the water phase was extracted with chloroform and the chloroform extract then chromatographed on paper. With the fresh corn sap two radioactive peaks were found, one of which was atrazine, the other which we were able to show was hydroxy atrazine by comparing the R_f of a synthetic sample of this produce to that found in the incubated mixture. With the boiled sap, however, only one peak was found and that corresponded to the original atrazine.

From these studies it was possible to demonstrate that the first product of the metabolic attack on the triazine herbicides was the hydroxy compound. It then became of interest to attempt to follow out this process in order to learn more about subsequent products of metabolism of the hydroxy compound. We speculated that the next step in the breakdown involved the oxidation of the hydroxy compound to a keto form resulting in a structure which would readily undergo hydrolytic cleavage of the ring. Careful study of the infrared adsorption spectra of the hydroxy compound clearly revealed the presence of a carbonyl stretching group at 1680 cm^{-1}. If the hydroxy compound existed only in the OH form, this particular band would not be expected. However, if rearrangement or oxidation occurred on this particular compound, then the carbonyl group would appear producing a structure susceptible to attack by hydrolysis.

It now appears possible to write some of the chemical reactions and structures of the compounds up through breakage of the ring. This is seen in the following reaction scheme.



It will be noted that the structure resulting from the hydrolysis of the ring would be highly unstable and susceptible to further attack giving release to radioactive carbon dioxide and affording products that would be further incorporated into the plant by enzymatic action.

In concluding the presentation of information on metabolism of triazines, it may be of interest to note that considerable variation in the ability of plants to metabolize these compounds has been found. It appears that the certain susceptible plants are much less able to metabolize the triazine than some of those that are resistant. In perennial plants tolerant to these compounds, one does not find an abundant production of $C^{14}O_2$ but rather an incorporation of the radiocarbon into plant constituents. This was brought home forcibly in the study of the metabolism of the triazine herbicides by trees and shrubby plants. Appreciable quantities of radiocarbon would be found in the leaves but upon extraction with the use of solvents to fractionate the radioactivity, the C^{14} was found to be widely distributed in many fractions.

Similarly differences in the ability of a given plant species to metabolize different triazines was noted. A major difference in rates of $C^{14}O_2$ production by corn when exposed to the different chlorine containing alkylamino triazines has been found.

Summary and Conclusions

Scattered published reports clearly indicate that plants like animals and microorganisms are fully capable of metabolic attack on organic chemicals to which they are exposed in their environment. Again, parallel with animals or microorganisms, the plant may carry out this metabolic attack by one of several means. The metabolism may take the form of a conjugation of the externally applied chemical with proteins or carbohydrates or with simpler compounds such as amino acids and the sulfur-containing amino acids. Similarly the compounds may undergo hydrolysis, hydroxylation and other chemical modifications. Of particular interest in this paper has been the matter of the plant's ability to carry out oxidation of externally applied materials. It has been shown by the experimental work reported that plants possess the ability to oxidize such chemicals as amitrole and amiben, 2,4-DB and the triazine herbicides. The evidence for this oxidation rests on the evolution of the radioactive carbon dioxide and the appearance of the C^{14} in normal plant constituents.

Metabolism of herbicides may be shown to be related to the mode of action of the drug. This comes about in the first instance where an innocuous compound is converted by the plant's metabolism to a compound of high biological potency, thus killing the plant or modifying its growth. In the second instance, the metabolism helps to reduce the toxicity of the compound and may serve in part at least as a basis of the tolerance of the plant toward the chemical. Complete oxidation of the compound to innocuous products is of importance at the practical level in that this serves to reduce the residue of that compound. The initial steps in the sequence of reactions leading to complete oxidation of the triazine herbicides has been partially worked out. The reactions have been shown to be dependent upon enzymes leading to organically unstable molecules.

This preliminary report attempts to summarize some of the information on metabolism of herbicides. It is hoped that this modest effort will serve as a stimulus to additional work in this field and the elucidation of complete mechanisms by which many of the herbicides are metabolized by plants.

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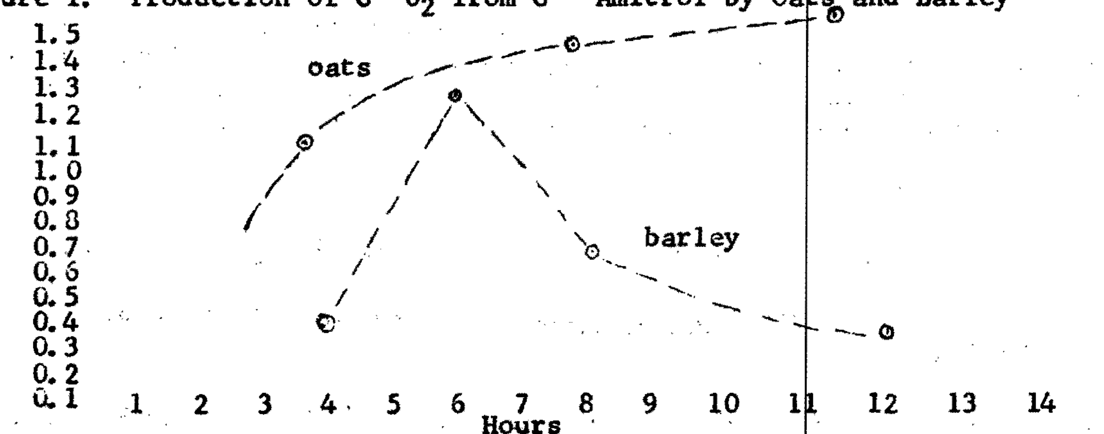
Figure 1. Production of $C^{14}O_2$ from C^{14} Amitrol by Oats and Barley



Weed Control In Suburbia

Howard H. Campbell[1]

I accepted this invitation to speak at your weed conference on home ground weed control because I believe that if we can more clearly understand each other's problems all of us will benefit; including the homeowner who lives in our new suburban America.

My comments today are based not only on my own observations, but also on those of my associates, especially Norman J. Smith, Nassau County Associate Agent, who won your annual weed control award a few years ago. In addition, the views that I am about to express reflect the ideas and suggestions of a number of other county agents who now work in urban settings here in the northeast.

Nassau County is a prime example of a county which has changed from a somewhat rural area to a suburban center since the end of World War II. It has been labeled the fastest growing county in the United States, and I have had the unusual experience of being in the middle of this change. In the past 10 years, Nassau's population has increased nearly 100%. Approximately 150,000 new homes have been added, along with 600,000 new residents. As a result of this change, about 25,000 acres of farm land was sub-divided into suburban homes.

Weeds which were primarily the problems of the farmers, are now problems of new owners. We have the same soil and the same weeds, but the relative significance of these weeds has changed.

To the farmers, the weeds were an economic problem because they reduced yields and increased the labor costs of producing vegetables. To the new homeowner, the weeds are not only an economic problem, but primarily a social problem. Here, I think we can create a new definition of a weed that will be more suitable with the times. Our definition of a weed originally was, "any plant growing where it is not wanted." This could be amended to include any plant which may endanger the social status of a homeowner. With this definition of a weed, it is easier to understand why weeds are more important to some people than they are to others. Crabgrass is more of a weed in some neighborhoods or developments than it is in others. If everybody has it, it is less important. However, if we look at a merion kentucky bluegrass development, then every other plant, including crabgrass which is growing in these lawns, can be considered a weed.

1
County Agricultural Agent, Nassau County, New York

To summarize this point, I think we can agree that weeds in home lawns are a relative problem depending upon the social status of the people who own these lawns.

At the present time, a majority of people are striving to improve their social status which makes weed control in the lawn a very important area of work for research and extension people. The people with whom we are dealing believe in science and are anxious to make use of scientific knowledge if they can obtain results. In the long run, any number of chemicals can be promoted and sold and used, but the only ones which will last are those which give results.

As one of our homeowners put it, "I've been having natural luck with my lawn, but I don't like naturalness. I want to know what I'm doing and what's going on."

Most of our homeowners are rational thinking human beings and although they have limited agricultural knowledge, they are alert enough to recognize the difference between good results and failures when they try to control weeds.

I believe that our home lawn weed problems can be divided into two areas. First, weeds which are a problem at the time of establishing a new lawn, and second, weeds which are a problem in maintenance.

Many of the weeds which used to be a problem in new lawns, can now be prevented by using materials to make a weed free seed bed. The use of calcium cyanamid has been a step in this direction, to kill weed seeds before the grass seed is planted. Excellent results have been obtained from cyanamid by many landscapers and homeowners. However, many are often disappointed because old grass clumps are not killed by the cyanamid treatment and these clumps destroy the uniformity of the new lawn.

The newer materials such as Vapam or VPM are more effective since they will kill weed seeds to a greater depth and will also kill the old sod residue from the previous lawn. Killing these old sod clumps is especially important if these clumps contain bentgrass and if the new lawn is to be 100% merion bluegrass. Bentgrass growing in a merion bluegrass lawn is one of our worst weed problems. How to remove bent from a merion lawn is a question that we have been hearing more and more frequently in recent years.

For establishing new lawns, I would like to describe a possible material which I believe our homeowners would appreciate being able to purchase. We need a material which:

1. Will kill weed seeds and residual grass plants to a depth of at least six inches.

2. Will disappear from the soil in a short period - - one weed would be most desirable.

3. Will be effective at lower soil temperatures in order to allow more early spring seedings.

4. Will be non-toxic to humans and pets, have a desirable odor and be easy to apply.

Although this is a big order, I feel sure that you research men will approach this before too long. Many people wonder why we don't have such a material now. Homeowners often believe in the impossible and sometimes we have to go along with their thinking.

The second area which I mentioned, is weed control as a part of home lawn maintenance. Here we have two separate problems. First, broadleaf weed control and second, annual and perennial grass control.

The broadleaf weed problem is much easier for a homeowner to handle today with the use of 2,4-D, mixed with 2,4,5-TP. This combination of materials has greatly improved the effectiveness of selective broadleaf weed control. Thousands of our homeowners have reported excellent results with this combination.

The second area of selective grass control is a horse of another color. How can I kill bentgrass? How can I kill ryegrass? How can I kill quack grass and nut grass? How can I kill annual bluegrass? How can I kill nimblewill? - - or we even get the question, how can I kill crabgrass? These are some of the popular questions which make us wonder how far behind we really are. The perennial grass problem we gladly turn over to you research people for the answers.

You know, it would be difficult to complete this paper without some mention of crabgrass. Crabgrass, I believe, is our number one problem indicator grass. In many home lawn situations, crabgrass is a result and not a cause. Here we have problems not only involving chemicals but also maintenance. Low fertility, low lime, low mowing, improper watering, all contribute in some way to the crabgrass problem. With crabgrass, herbicides have helped in many situations, but they are not a substitute for proper management. This is one of the most difficult points which every homeowner must face if he is going to get the results he is expecting.

Applying materials which prevent crabgrass from growing is desirable but that in itself does not create a good grass. Applying materials which changes crabgrass from green to brown does not, in itself, improve the lawn. Good management is still the main part of the total crabgrass control program, if we are to kill crabgrass for a purpose. Killing crabgrass just for the exercise of killing crabgrass is pointless, but we have a number of homeowners who are doing just this. I remember one homeowner this year who was very disappointed because his crabgrass froze the night before he got around to apply a weed killer.

It is, indeed, unfortunate that many of our homeowners are over sold on killing crabgrass and under sold on the use of lime, fertilizer and other management practices which will improve the lawn and control weeds. No doubt, much good is coming out of selective crabgrass killers, but let's not under sell the total program that is necessary to properly improve the home lawn.

One last area which I believe important is the application of materials, including weed killers to the home grounds. Getting homeowners to apply materials at the proper rate is a problem for everybody, the research men, county agents, manufacturers and homeowners. If materials are not applied properly, our efforts are cooperatively wasted. If you want to see a sight in the spring, take a ride around the developments in Nassau County and observe the striped landscape. You can find almost any design of modern art on lawns caused by a nitrogen response or nitrogen injury. If weed killers are applied as haphazardly as our fertilizers, I wonder sometimes, if anyone is getting satisfactory results.

Our homeowners may be precision drivers at 50 miles per hour, but when they are slowed down to 2 to 3 miles per hour behind a lawn spreader, they are in a new world.

We spend years researching and teaching, then send a home gardener across his lawn without proper direction. He very often does not know what he has covered or if he has covered an area at all. So why not color our herbicides so that the homeowner will treat once and not twice or not at all. You may think this point is not important, but you are a professional and you may not realize how much trouble a greenhorn can get into.

Another question which is a real corker, and we frequently get this type of question, "At what number should I set my spreader on for XYZ material", or "I have one man's material and another man's spreader, now what number should I set it on." One lady who attended our turf field day this year said, "I use number 3 for everything, do you think that's OK?"

Any improvement that you can make in equipment will be appreciated by county agents and homeowners. It seems absurd to use precision in research, precision in selling and precision in teaching, then turn the homeowner loose to the disappointment of all of us. If our present lawn spreaders cannot be improved, let's make a fool-proof applicator, possibly where the material container is an integral part of the application equipment. With this system, the flow-ability of materials could be predetermined and a package could be sold which could be applied without error.

Regarding the use of liquid and dry materials, let's suggest teaspoons and tablespoons and cupfulls, pints and quarts. Very few homeowners have facilities to weigh out dry ounces and pounds. With some materials, one person at the factory could do the weighing one time for several thousand others.

One further point on materials - - the label. I believe the label should first answer one question - how much. If people are going to do a limited amount of reading, let's get this point across first. Also on labels, if you have a weed killer which entails certain precautions or limitations, let's be proud of the fact that we know what they are. Don't hide it in fine print. I believe that a home gardener is entitled to a full explanation of what to expect, and in many instances, why to expect certain results. Incidentally, most of the county agents who replied to my questionnaire were in complete agreement on these points regarding the label.

Let me also mention some of the specific comments which were made by county agents, who are sincerely interested in performing a fine job in nearby counties which have an urban population.

1. Several stated that many commercial concerns emphasize trade names rather than the actual ingredients. This often causes confusion.

2. There is often over emphasis upon making the lawn weed control job look too easy. This causes frustration for the homeowner as well as the agent.

3. Too often we hear about misinformation stating that the material is a cure-all for everything when in fact it is not. This doesn't help anybody.

4. Finally, in some instances, the label on herbicidal materials which are recommended state that the purchaser should consult his county agent for more complete information about using the material. This is often embarrassing because the material may not even be recommended in that county agent's state.

I would suggest, therefore, that the Extension Service specialists in these northeastern states get together and make regional recommendations on weed control practices for suburban residents. This will not only assist agents, but also be of great help to the manufacturers and distributors of materials.

In conclusion, we in Extension, want you to feel that we are all a part of the same team. All of us want to help home gardeners make the best use of agricultural knowledge. As we continue our work with home gardeners, I'm sure we are acquiring a large number of satisfied customers. I know of no other group who are more grateful for our help than satisfied homeowners. They frequently express sincere thanks for our unbiased opinions. Although this group is relatively new, I feel certain that they will be an important asset to use in our future research and extension programs for agricultural chemicals used on and off the farm. Let's give him the results - - not just materials.

PROMISING NEW CHEMICALS FOR WEED CONTROL

Stanford N. Fertig 1/

INTRODUCTION:

The development of promising new compounds for weed control and new uses for many of the older ones continued at a rapid pace during 1960. The greater selectivity to crops, the results on previously resistant weed species, changes in application techniques, combinations of herbicides for more effective results and even stimulation of crop growth over that expected from the removal of weed competition made 1960 an exciting year. Also to be recalled are the surprises, the compounds to which we pinned great hopes in 1959 but which failed this year. There is no doubt but what "Mother Nature" with all her variables of temperatures, rainfall, humidity, soil type, seed germination, etc., will continue to exercise a degree of skepticism on our judgment of what looks good and/or bad.

The following is an attempt to summarize some of the more promising developments for the 1960 growing season.

Granulars and Combinations

New and promising developments continue in the areas of aquatic weed control, vegetable and nursery crops, brush control and air application, particularly with respect to granular compounds. With improvements in equipment and formulation, increased usage can be anticipated.

Combinations of herbicides show increased effectiveness over the use of a single compound for the control of a number of perennial weed problems. Some of these will be discussed later in this paper. Others, including CIPC plus Randox, dalapon plus Dinitro and 4(2,4-DB) plus dalapon have been covered by previous reports.

NEW CHEMICALS WITH PROMISING USES:

Amiben

The liquid amine formulation as a pre-emergence treatment looks very promising for annual broad-leaved and annual grass control at 3 to 4 pounds per acre on carrots, black-eyed peas, lima beans, pumpkin, snap beans and soybeans. At rates of 2 pounds per acre favorable results have been obtained on cucumbers. The weed control was excellent, as was the stand of plants, weight of plants, numbers and weight of fruits.

The granular formulation has looked promising on crucifers, peppers, sweet potatoes, tomatoes and ornamentals, at rates of 3 to 8 pounds per acre.

1/ Professor of Agronomy, Cornell University, Ithaca, New York.

Applications may be made at time of transplanting or as lay-by treatments. In the ornamental field, peonies are reported as tolerant; pansies are not tolerant.

For optimum results with Amiben, moisture is essential. Irrigation or rainfall sufficient for good crop growth is sufficient for weed control.

Some weed species reported resistant to Amiben are: Galinsoga, Carpetweed and Morning Glory. Some grass species may require higher rates for satisfactory control: Foxtail and Barnyard Grass.

Amitrol-T

There is a marked increase in the activity of Amitrol-T over Amino Triazole in the powder formulation. It is more effective on cattails, (Equisetum spp.), milkweed, leafy spurge and cypress spurge than the powder and is equally as effective on Canada Thistle, hoary cress, and perennial sow thistle.

Amitrol-T at 2 pounds per acre as a plow-down treatment followed by Atrazine at 2 pounds pre-emergence looked excellent for quackgrass control in corn. Early post-emergence cultivations (1 to 2) are essential for good control.

Some reports indicate promising control on nutgrass with Amitrol-T.

Amizine

Looks promising for general vegetation control at rates of 10 to 12 pounds active per acre. Several reports indicate effective weed control in woody plant nurseries, forest plantations, ornamental plantings, orchards, and around highway guard rails, route signs, etc. For nursery or forest plantation weed control, 4 pounds of active chemical per acre as a directed spray has controlled most weed problems without injury to woody plants. Most coniferous and broad-leaf trees and shrubs are sufficiently tolerant.

Some ornamentals reported as susceptible include privet, honeysuckle and lilac.

Casoron (Niagara 5996)

This compound shapes up as a promising pre-emergence herbicide on a number of different crops. At rates of 3 to 4 pounds per acre, the control of annual broad-leaved weeds and annual grasses has looked good in corn, beans (lima and snap), peas, potatoes, soybeans and sweet potatoes.

The most promising approach for Casoron appears to be treatments that are post-emergence to the crop but pre-emergence to the weeds. A "weed-free" situation is a "must" at the time applications are made. Using this approach, promising results were reported in cantaloupe, celery, cucumbers, gladioli, peppers, sweet corn and tomatoes.

Soil type would appear to be an important factor in the initial and residual effectiveness of Casoron. Applications on the heavier soil types have resulted in less crop injury than those on light or sandy soils.

Promising results have also been reported on cranberries, providing treatments are made in the spring prior to the start of weed growth.

Dacthal

This compound received many favorable reports as a pre-emergence treatment of weed-crop situations at rates of 4 to 12 pounds active per acre. It continues to look good for the control of crabgrass in turf. The reported injury to turf grasses including bentgrass, Kentucky bluegrass, red fescue and redtop has been variable -- from none to serious with some species.

Good weed control was reported for lima beans when applied just after seeding, for onions on mineral soils, for transplanted peppers either as an over-all spray or a granular, for tomatoes as a post-planting treatment and after the last cultivation, on seeded cabbage and broccoli, and as a pre-emergence on peas.

Favorable results were also obtained during the 1960 growing season for annual weed control in summer seeded alfalfa, annual grass control in field corn and in soybeans.

In the work with ornamentals, nursery stock shows good tolerance up to 12 pounds per acre and gladiolus from 2 to 8 pounds. The control of weeds has been variable.

Dicryl (Niagara 4556)

Dicryl has been promising as a post-emergence herbicide for carrots, celery and galdioli. Application rates of 3 to 4 pounds active per acre, when carrots have developed their first true leaves, have been effective. Also, good weed control has been reported on cucumbers with application rates of 4 to 8 pounds per acre at time of cucumber emergence.

In the treatment of carrots, transplanted celery or gladioli, the size of the weed species is important. The broad-leaved species should not exceed two inches in height, while annual grasses should not exceed 1 inch if satisfactory control is to be realized.

Analogs of Eptam: R-1607, R-1862, R-1870, R-2007, R-2060, R-2061.

These compounds have shown excellent activity against a number of weed species. Soil incorporated treatments at rates of 3 to 6 pounds active per acre may find a place on such crops as beans, beets, corn, crucifers, spinach, strawberries, tomatoes and tobacco. R-1607 looked promising as a lay-by on potatoes.

The very promising results on nutgrass are most encouraging. Good control has been reported in beans, corn and other crops. Soil incorporation immediately after application is emphasized.

The granular materials show equal effectiveness for weed control. The crop injury to equal rates of granular and spray have been variable.

Falone (3Y9), B-528 and B-562

The 1960 results with Falone and B-528 as pre-emergence treatments on corn were very promising. Rates of 2 to 6 pounds per acre as liquid or granular applications were equally effective on a number of broad-leaved and annual grass species.

Good results were also reported on white potatoes, strawberries, on some ornamentals. The 10 percent granular formulation caused no injury to yews or hemlock in field plantings or beds. Residual control lasted 6 to 9 weeks.

Post-emergence applications of B-562 looked promising on lettuce on mineral soils. Weeds up to one-inch tall were effectively controlled with no damage to the lettuce.

Hercules 7175

Hercules 7175 has shown promise for pre-emergence weed control in white potatoes, woody plant control with soil applications and as a soil sterilant. For pre-emergence weed control, rates of 2 pounds per acre look promising to a wide range of weed species. Seasonal control of vegetation has been obtained with rates of 20 to 40 pounds per acre.

L-13489, L-31684 and L-34314. Eli Lily and Co.

Preliminary results show L-13489 at rates of 20 to 30 pounds per acre and L-31684 at 2-1/2 to 5.0 pounds, resulted in good control of seedling crabgrass in turf with no turf injury.

In vegetable crops, L-34314 as pre-emergence applications of 2 to 6 pounds resulted in satisfactory control of foxtail, millet, goosegrass, pigweed and smartweed. Beans, cabbage, cucumbers, mustard, peas, peppers, radish, and turnips and to some degree cantaloupe and carrots were tolerant of rates as high as 4 to 6 pounds per acre.

Monsanto CP-17029

This compound shows excellent promise on both broad-leaved and grass species. Application of 2 to 3 pounds active per acre pre-emergence has resulted in 6 to 8 weeks of residual control. Research results show corn and soybeans to be tolerant.

Niagara 2995

This compound has demonstrated good pre-emergent activity against both annual broad-leaved and grass species. Specific crop tolerance has not been clearly defined but the compound has shown enough promise to be checked further in 1961.

Silvex (2,4,5-T Propionic)

The effectiveness of 2,4,5-TP in controlling a number of heretofore hard-to-kill species is most promising. At rates of one pound per acre or less, bedstraw (*Galium mollugo*), dog fennel (*Anthemis cotula*), white cockle

(*Lychnis alba*), cinquefoil (*Potentilla recta*), daisy fleabane (*Erigeron canadensis*), wild carrot (*Daucus carota*), ox-eye daisy (*Chrysanthemum leucanthemum*), and grass-leaved stitchwort (*Stellaria graminea*), were controlled. At higher rates, with repeat applications, promising results have been obtained on leafy spurge (*Euphorbia esula*), cypress spurge (*Euphorbia cyparissias*), and on knapweed (*Centaurea maculosa*).

Triazines: G-32292, G-32911, G-34161, G-34162, G-34690, G-34696, G-34698, Atratone, Atrazine, Ipazine, Ipatone, Prometone and Trietazine.

For the control of broad-leaved weeds and annual and perennial grasses, the Triazines have shown outstanding promise.

At rates of 1 to 2 pounds active per acre as at planting, pre-emergence and early post-emergence treatments on corn, the control of broad-leaved and annual grass species has been excellent.

For quackgrass control in corn, applications of 2 pounds of Atrazine before plowing followed by 1 to 2 pounds pre- or early post-emergence has resulted in seasonal control. Applications of Amitrol-T at 2 pounds before plowing plus Atrazine at 2 pounds as a pre-emergence treatment were just as promising when accompanied by early post-emergence cultivation.

A number of experiments show early post-emergence applications of Atrazine at 3 to 4 pounds to give seasonal control of nutgrass.

In orchards, the triazines in combination with amino triazole, dalapon and diuron show promise on apples. pears, plums, cherries and peaches. These are applied as early spring applications or following cultivation.

Promising results are also reported for ornamentals and nursery stock. The granulars look particularly promising for this field of weed control.

There is a difference in the selectivity of the range of compounds avilable. Research results and observations during 1960 show good weed control in lima beans with Trietazine without injury, possible control of horse nettle, a tolerance of seedling legume species, pre- and post-emergence applications resulting in malformations in corn and variable results, as with other compounds between granular and spray applications.

Velsicol 58-CS-11

Field tests with this compound show good herbicidal activity on many broad-leaved weeds and certain grass species.

Tests on dog fennel growing in wheat and barley resulted in good control at 1/4 to 1/2 pound per acre. Other weed species growing in cereals on which control is indicated include stinkweed, wild buckwheat, mustards, horsetail and corn spurry.

As pre-emergence applications of 2 to 4 pounds to areas of grass seed crops infested with downy brome (Bromus tectorum), the control was promising.

At rates of 10 to 20 pounds per acre, good control of field bindweed has also been reported.

Zytron

A summary of the 1960 research work shows Zytron to be a promising and versatile compound. At rates of 15 to 30 pounds per acre as a pre-emergence spray, crabgrass control is good. The granular and liquid forms showed equally good results. These pre-emergence treatments have also been effective on carpet weed, chickweed, dooryard knotweed, pigweed, purslane, and Veronica species. Post-emergence applications as emulsifiable sprays have resulted in good control of chickweed and henbit on turf areas.

In the vegetable group, good weed control was reported for carrots when applied a few days after seeding, for lima beans when applied just after seeding (12 to 18 pounds), and as a pre-emergence treatment for annual weed and grass control in egg plant, peas and spinach, at 6 to 10 pounds per acre. Lay-by treatments on potatoes for late germinating annual grasses also looked good.

Excellent results were reported from pre-emergence applications of Zytron plus dinitro on soybeans. A definite growth stimulation over and above the response expected from weed control was obtained with soybeans.

Zytron also appears to be effective for the control of some annual weeds and grasses in ornamental nursery plantings and forest tree nursery seedling beds.

THE EFFECTS OF ADDED PENETRANT AIDS AND WETTING AGENTS ON THE RESPONSE OF QUACKGRASS (*Agropyron repens* (L.) Beauv.) TO DALAPON

by

J. K. Leasure[1]

INTRODUCTION

Since its introduction in 1953, 2,2-dichloropropionic acid (dalapon) has been of considerable interest because of its practical selectivity with grasses. In addition to many field trials, a large number of more detailed experiments have been conducted in attempts to determine its sites of action in plants, the method by which it is translocated in plants, and its ultimate fate in both plant tissue and soil. A number of experiments have been conducted with and without wetting agents. The present study was undertaken to determine the effect of some surface active agents on the translocation of sodium dalapon into the rhizomes of quackgrass (*Agropyron repens* (L.) Beauv.), as part of a continuing progress to improve the effectiveness of dalapon formulations.

REVIEW OF LITERATURE

There is ample evidence in the literature that spray additives which have surface-active characteristics can increase the effectiveness of a number of herbicides(2, 5, 6, 7, 11, 12).

It has been pointed out(4) that differences may exist in the effectiveness of herbicide formulations even with equal wetting, and that considerable care in the selection of a wetting agent is required.

Daniels(3) refers to a relationship existing between the ionic character and the relative polarity of a compound which suggests that the addition of suitable surfactants to a strongly ionic, hydrophylic, polar compound such as sodium 2,2-dichloropropionate (sodium dalapon) might very well cause such a formulation to become more compatible with non-polar materials such as those found in the cuticle of plants.

[1]The Dow Chemical Company, Midland, Michigan.

Robbins et al[10] state that "increase in polarity enhances the apparent reactivity (of a herbicide) whereas increase in its oil-like (a-polar) properties promotes penetration."

They conclude that since the two processes are apparently opposed, there must be an optimum point in the balance between them; and this in reality represents a compromise between toxicity and compatibility with the cuticle.

Orgell[9] has observed that cationic and anionic surfactants differ markedly in their effects on absorption of acidic compounds, and Staniforth[11] states that non-ionic wetting agents differ in action from that of sodium laurel sulfate - an anionic wetting agent.

Currier's observation[1] that root absorption of dalapon is enhanced by the addition of a surfactant is of interest since roots are normally readily wetted by water, and thus perhaps confirms Ennis' earlier observation[4] by indicating some effect on root cell protoplasm. Knowledge of the effect of surfactants in herbicidal solutions is far from complete; and a 1954 summary by Currier still represents the state of the art fairly well.

Foy[5] using both C^{14} and Cl^{36} labelled dalapon demonstrated the advantages of using wetting agents with dalapon. For example, on the basis of growth inhibition, it appeared that as much dalapon was absorbed by corn in one hour from sprays containing a surfactant as in two weeks from a solution without a surfactant.

Jansen[8] found a wide range in response to dalapon by both soybeans and corn in tests using 63 different wetting agents in combination with dalapon.

MATERIALS AND METHODS

Prior to the start of this experiment, Jansen's data had been reviewed and, on the basis of his results, a number of surfactants which had improved the herbicidal effects of dalapon on corn and soybeans were tentatively selected for use. Some of these were not readily available, so a further selection was made, and the following surfactants were obtained:

Surfactant	Type	Produced by
Duponal WA Flake	Anionic	E. I. du Pont de Nemours and Company
Ethomeen S-15	Cationic	Armour Chemical Corporation
Tergitol TMN	Non-ionic	Union Carbide Corporation
Polyglycol 26-2	Non-ionic	The Dow Chemical Company

Tests to determine retention on the leaves of quackgrass and tests to determine the required dosage of dalapon-2-C^{14} showed that the non-ionic surfactants were superior to both the ionic ones. Accordingly, Tergitol TMN and Polyglycol 26-2 were used in the rest of the experiments.

One of the early tests which gives some information concerning the effect of surfactants on the penetration of leaf surfaces was run as follows:

A group of quackgrass plants in the five-leaf stage was selected for uniformity. Glass vials 5 mm. in diameter and 70 mm. in length were filled with various labelled dalapon and wetting agent solutions, and the third leaf of each quackgrass plant was inserted into a vial to a depth of 50 mm. Evaporation and plant uptake were measured after 24 and 48 hours. After 48 hours, the plants were harvested and the various parts were examined for radioactivity using liquid scintillation counting. For the remainder of the tests, formulations containing unlabelled dalapon sodium salt at a concentration of 10 pounds in 60 gallons were used. A range of wetting agent concentrations of 0, 0.05%, 0.1%, and 0.2% wetting agent in the final herbicide solution was used. These percentages are in the higher range of the concentrations of wetting agent used in field applications of dalapon at recommended rates.

This experiment was conducted with pot-grown plants of quackgrass (Agropyron repens (L.) Beauv.). All test plants were grown from two node sections of quackgrass rhizomes which had been selected for uniform size and weight from a clone. The test plants were produced and held after treatment in a Percival controlled environment chamber with a day temperature of 78°F. and a night temperature of 66°F., having three four-degree temperature steps between the extremes. The plants were grown under a twelve-hour day length with a maximum intensity of 3,900 foot-candles at bench height. Light intensity was also regulated through three increments per cycle, with nine hours of maximum intensity light during each 24-hour period.

Plants were selected for uniformity of sprouts shortly after emergence, and again at the three-leaf stage. A final selection made when the test was started resulted in an extremely uniform group of plants in the six-leaf stage of growth, each with a three-leaf shoot at the second node. Preliminary trials gave coefficients of variation of from eight to ten percent for plant height, weight, and rhizome weights. Six replicates were used for each treatment.

Test solutions were prepared by dispersing the wetting agent in water, and diluting to the required concentration, then adding unlabelled sodium dalapon to a concentration equivalent to 10 pounds to 60 gallons.

A sample of 2-C^{14} labelled sodium salt of dalapon having a specific activity of 0.98 millicuries per millimole was used for the test. The solution employed contained 1.35 microcuries per milliliter.

An area 5 mm. by 50 mm. on the upper surface of the third leaf of each test plant was walled with lanolin. This area was then supported in a horizontal position, and flooded with one-half milliliter of the proper dalapon-wetting agent solution. A two hundred lambda aliquot of the 2-C^{14} labelled sodium dalapon solution was added to the wetting agent solution on each leaf, after which the leaves were allowed to dry.

It was thought that perhaps the herbicide might be retained by the lanolin ring, or that the wetting agents might affect such a retention. This was checked in the following manner. Lanolin rings were formed on thin glass cover slips, and the rings were then filled with dalapon-2-C^{14} solutions in water and with various wetting agents. After standing for one hour, the cover slips were washed under running water for 30 seconds. The cover slips were then broken with tweezers and dropped into vials of scintillation solvent. After shaking to dissolve the lanolin, the vials were counted and background counts were obtained. It was considered that the lanolin ring per se had no interaction with either the herbicide or the wetting agents used.

After five days, the plants were dissected and the individual leaves, stem, rhizomes, and roots were cut with shears into one-half inch segments. The various parts, except for the treated leaves, were ground in a glass homogenizer. The pieces of treated leaf (with the lanolin wall) were placed into vials containing 5 ml. of water containing sodium carbonate slightly in excess of saturation. The vials were heated to approximately 99°C., placed in a freezer at 18°C. for 24 hours, and then crushed with a stirring rod. After grinding or crushing, each sample was centrifuged and the supernatant liquid removed for analysis.

Counting was done in a Packard tri-carb automatic scintillation counter using a solvent system consisting of 70% redistilled toluene and 30% absolute ethanol, and which contained 4.0 grams of 2,5-diphenyloxazole and 0.1 gram of 1,4-bis-2-(5-phenyloxazolyl)-benzene per liter. One-half ml. of supernatant liquid from a sample preparation was added to 19 1/2 ml.

33.

of scintillation solution, dispersed by shaking, and counted at 5°C. for 30 minutes (or to a count of 100, 000 if this was reached first).

C^{14} standard solutions and scintillation blanks were used, and the counting efficiency (which was determined for each counting run) varied from 54% to 57%.

Although other workers have reported that dalapon is easily leached from plant tissue, the sample preparation procedure was checked to determine whether or not a disproportionate amount of dalapon-2-C^{14} remained in the solid portion. Samples were ground, dispersed in 10 ml. of water and centrifuged. An 8 ml. aliquot was removed, 8 ml. of water were then added, and the solids redistributed by shaking. This was centrifuged and another 8 ml. aliquot removed. This was done a total of four times. The various aliquots were examined by liquid scintillation counting. By successive extractions, it was determined that the dalapon-2-C^{14} was readily equilibrated in the system.

RESULTS AND DISCUSSION

Results obtained using different dalapon-2-C^{14} and wetting agent combinations in the leaf immersion uptake test are shown in Table 1.

Table 1.

The Uptake of Dalapon-Wetting Agent Solutions
By the Third Leaf of Five-Leaf Quackgrass Plants Through Leaf Immersion

Formulation	% Wetting Agent in Solution	Uptake in 24 hrs.	Uptake in 48 hrs.	Evaporation in 72 hrs.
Dalapon alone	0.0	0.11 ml.	0.23 ml.	0.11 ml.
Dalapon plus P-26-2	0.05	0.31	0.67	0.12
	0.1	0.58	>2.0	0.09
	0.2	0.98	>2.0	0.10
Dalapon plus Tergitol TMN	0.05	0.44	0.71	0.11
	0.1	0.49	>2.0	0.13
	0.2	0.83	>2.0	0.11

These results show that evaporation over a 72-hour period is approximately 0.1 ml. and of little significance in comparison with the other measurements. The results of added wetting agent are striking, and show that the addition of non-ionic surfactants increases penetration of the leaf surface when the leaf is immersed in the solution. Radioactivity counts were proportional to these uptake data and confirmed that the observations represent uptake rather than evaporation.

For the leaf surface tests, the applications of the dalapon and surfactant formulations were made to the third leaf of quackgrass plants in the six-leaf stage. After five days, the various plant parts were examined by liquid scintillation counting. The results obtained with dalapon alone are shown in Tables 2 and 3.

Table 2.

The Net Counts Per Minute
Obtained From Leaves of Quackgrass Plants
Treated With C^{14} Labelled Dalapon in Water With No Added Wetting Agent
(Background Count = 28.3 cpm.)

Replicate	First Leaf	Second Leaf	Third* Leaf	Fourth Leaf	Fifth Leaf	Sixth Leaf
1	26	37	8684	163	327	346
2	20	38	7872	216	355	337
3	25	37	7432	206	329	295
4	24	31	8425	189	273	332
5	27	40	6915	174	285	380
6	20	28	8439	225	286	256
Average	23.7	35.2	7978	195	309	324
Standard Deviation	3.1	4.2	679	24	32	43
C.V. (%)	13.1	11.9	8.5	12.3	10.4	13.3

*Application made to third leaf.

Table 3.

The Net Counts Per Minute
Obtained From Roots, Stems and Rhizomes of Quackgrass Plants
Treated* with C^{14} Labelled Dalapon in Water with No Added Wetting Agent
(Background Count = 28.3 cpm.)

Replicate	Stem	Untreated Shoot	Old Rhizome Section	New Rhizome	Roots
1	36	409	20	82	24
2	26	470	17	76	18
3	30	456	21	60	22
4	33	439	26	69	27
5	29	552	24	67	19
6	33	472	16	70	23
Average	32.2	466	20.7	70.7	22.2
Standard Deviation	3.3	48	3.9	7.6	3.3
C.V. (%)	10.2	10.3	18.9	10.8	14.9

*Application made to third leaf. (Same plants used as for Table 2 data.)

The results obtained using dalapon with two non-ionic wetting agents each in three different concentrations were compared with these shown for dalapon alone by calculating the percent of applied dalapon-2-C^{14} which was found in each of the several plant parts.

A number of comparisons are possible in this manner, some obviously of more interest than others. Translocation into new rhizomes and through old rhizomes into untreated shoots is of considerable importance in obtaining control of quackgrass. The effectiveness of the wetting agents in influencing movement into these parts is shown in Table 4.

Table 4.

The Percent of Applied Radio-Dalapon
Which Was Found in the Rhizomes, Roots, and Untreated Shoots*

Formulation	% Wetting Agent in Solution	New Rhizome	Old Rhizome	Untreated Shoot	Roots
Dalapon Alone	0.0	0.74	0.22	4.9	0.26
Dalapon with P-26-2	0.05	1.35	0.53	7.3	0.28
	0.1	1.92	0.67	8.4	0.17
	0.2	2.94	0.81	10.5	0.24
Dalapon with Tergitol TMN	0.05	1.43	0.49	6.9	0.22
	0.1	2.05	0.73	7.7	0.26
	0.2	3.65	0.94	9.4	0.31

* Application made on third leaf of six-leaf plants of quackgrass.

These experiments clearly showed that the addition of selected non-ionic wetting agents to the formulation resulted in increased movement of dalapon into the rhizomes and that the results obtained with the two wetting agents were quite similar.

The accumulation of dalapon in young tissue was also markedly increased by the addition of non-ionic wetting agents, and such increases are shown in Table 5.

Table 5.

The Percent of Applied C^{14}-Dalapon
Which was Found in the Leaves Above the Treated (Third) Leaf

Formulation	% Wetting Agent in Solution	4th Leaf	5th Leaf	6th Leaf
Dalapon Alone	0.0	2.0	3.2	3.4
Dalapon plus P-26-2	0.05	2.4	3.9	11.7
	0.1	3.9	5.6	16.5
	0.2	6.3	8.2	24.4
Dalapon plus Tergitol TMN	0.05	2.2	2.6	9.2
	0.1	6.0	6.6	16.1
	0.2	10.8	11.9	26.2

Here, as shown before, the use of the wetting agents resulted in increased accumulation of dalapon-2-C^{14}.

The comparisons for lower leaves, stems and roots were also made, and in each instance the addition of wetting agent increased the amount of radioactivity. The differences were quite large in some cases, probably because the amount of radioactivity found in these plant parts was quite low when no wetting agent was used. In every instance, the amount of radioactivity which remained in the treated leaf was less when wetting agents were added than when dalapon alone was used, indicating increased uptake by difference.

These data show clearly that the addition of a non-ionic wetting agent to the formulation used in this experiment markedly increased the uptake and translocation of dalapon-2-C^{14}.

The amount of dalapon-2-C^{14} translocated above and below the treated leaf was determined by computing the net count per minute for the appropriate plant parts (sample average net count per minute times the dilution factor used in preparing the sample) then comparing the count beyond the treated leaf with the total count. The percent of applied dalapon translocated above the treated leaf and the percent translocated below the treated leaf are shown in Table 6.

Table 6.

The Translocation of C^{14} Labelled Dalapon in Formulations With and Without Added Wetting Agents

	Dalapon	Dalapon with P-26-2			Dalapon with Tergitol TMN		
	Alone	0.05%	0.1%	0.2%	0.05%	0.1%	0.2%
Percent of applied dalapon translocated above treated leaf.	8.7	17.4	26.1	38.5	14.0	27.5	49.7
Percent of applied dalapon translocated below treated leaf.	7.1	13.4	19.0	28.9	10.4	18.0	29.2

These data show several things in addition to the obvious influence of added wetting agent. First, although both non-ionic wetting agents performed similarly, when formulations containing the low rate of wetting agent were used, the use of Polyglycol 26-2 resulted in greater accumulation of C^{14}-dalapon in the various plant parts than did the use of Tergitol TMN. The reverse was evident at the high rate. It would probably be difficult to establish the significance of this on the basis of these data alone, but the same trend existed in several preliminary tests using a number of different concentrations of both wetting agents from 0.01 to 0.5 percent. Surface tension measurements showed that at 0.2% in the spray solution, Tergitol TMN reduced surface tension more than did Polyglycol 26-2, while at concentrations of 0.05% and less the reverse was true. This may indicate that penetration (as affected by surface tension) is a major factor influencing the results obtained.

A study of the amount of dalapon translocated into the new rhizomes shows that although the amounts accumulated increased with added wetting agent, there was a slight decrease in the percentage of translocated dalapon which moved to the rhizomes. This also would tend to support the hypothesis that the surface active agent influenced penetration more than translocation and that whatever conditions limit the transport of dalapon-2-C^{14} into a rhizome still appeared to be limiting even when wetting agents are used in the formulation.

Second, significant amounts of dalapon-2-C^{14} were translocated through the rhizome to untreated shoots. Not all shoots can be equally well covered by a field spray, and a number of quackgrass shoots are normally connected by rhizomes. The transport of dalapon from one shoot to another through the rhizome section may tend to equalize a less than perfect spray application. In these experiments, as little as 0.05% of a non-ionic wetting agent in the spray solution increased the movement of dalapon-2-C^{14} into an untreated shoot by nearly 50%, while 0.2% in the spray solution increased movement into an untreated shoot by nearly 100%.

Movement into new rhizomes followed the same pattern, with the addition of 0.05% wetting agent resulting in more than 80% increase in accumulation of C^{14}-dalapon, while the addition of 0.2% wetting agent resulted in at least four times the accumulation of radioactivity obtained with formulations containing no wetting agent.

Movement of dalapon-2-C^{14} into the leaves was increased more by the addition of wetting agents than movement into and through the rhizomes, but it is felt that these movements (into rhizomes and through rhizomes to untreated shoots) may be critical in evaluating the herbicidal effectiveness of dalapon on quackgrass.

SUMMARY

Tests using 2-C^{14}-labelled dalapon formulations with and without non-ionic wetting agents resulted in a definite increase in the amount of dalapon-2-C^{14} recovered from rhizomes, untreated shoots and leaves. These increases in the amount of dalapon translocated were measured on uniform plants under conditions which avoided such variables as differences in leaf area covered by droplets of equal volume but with different surface tensions and differences in the amount of formulation applied per plant resulting from the influence of the wetting agent in retention of the formulation by the leaf.

Erratic results have been obtained from time to time in field applications of dalapon. These tests, conducted under controlled conditions with uniform plants, emphasize the importance of adequate foliage wetting. It is felt that the wetting agent is needed to wet the water, not the chemical, hence all concentrations reported here were percentages of the spray volume.

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RECENT DEVELOPMENTS IN THE USE OF VEGADEX[1]

R. E. Althaus[2] and L. S. Gleason[2]

Since the introduction of Vegadex (2-chloroallyl diethyldithiocarbamate)(CDEC), its use as a herbicide for vegetables has been on a constant increase. Grower acceptance has been due chiefly to its versatility on a wide range of vegetable crops both from the standpoint of weed control and crop tolerance.

Its initial use was intended primarily for pre-emergence weed control applied as sprays. With the advent of granular formulations, additional usage has been directed toward transplant and other stages of crop post-emergence applications.

My purpose today is to discuss recent developments with respect to new uses and the expanded use for multiple applications.

To date 33 crops are approved for use, and several more will be submitted for label registration. All the uses now listed on the label are approved for both emulsifiable and granular formulations. The emulsifiable formulation of CDEC is supplied as a 4 pound per gallon concentrate, and the granules contain 20% CDEC. Granular formulations have proven to be equally effective as sprays, however, uniform distribution is essential (1).

It has been recognized from the early developmental stages that the performance of Vegadex is enhanced under moist soil conditions. Since many vegetable growers irrigate and also because many of the vegetable production centers are in areas of adequate rainfall, this has not been a serious deterrent to its use but has contributed to occasional failures. The moisture requirement for granules and for sprays is equally important.

In areas where furrow irrigation is practiced, weed control has been erratic. The movement of Vegadex through the soil is now being explored intensively.

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[1]Registered trademark of the Monsanto Chemical Company

[2]Monsanto Chemical Company, St. Louis, Missouri

The most recent label registration amendments list the following crops:

Pre-emergence Application

tomatoes	direct seeded
cantaloupes	" "
okra	" "
field beans	Wyoming only (Incorporate 1-$1\frac{1}{2}$")

Post-emergence Application

spinach	second application
tomatoes	transplants
celery	second application
ornamentals	
yews	
privet	
junipers	

Additional studies have been completed which should permit future label claims for cucumbers, transplanted peppers and tomatoes at lay-by and possibly several other uses pending successful results with respect to the absence of residues.

Two of the recently approved uses involve a second application. The use of Vegadex under a 2 application program is becoming widely accepted in areas of muck grown celery. This procedure was developed with the cooperation of several large celery growers in Florida. The celery transplants are overhead irrigated immediately after setting and as soon as soil conditions permit, the Vegadex is broadcast sprayed over the rows to moist soil. In approximately 3 weeks the fields are fertilized, cultivated and a second directed spray or granules are applied to the celery. Following the second application, the fields may or may not be sub-irrigated depending on surface moisture conditions at the time of application to insure good movement of the Vegadex to the weed seed zone. Granular formulations have proven to be as effective as sprays and some growers will use granulars to minimize any danger of burning the leaves due to the solvent. Some growers elect to make the first application of Vegadex prior to, rather than following, overhead irrigation.

The second application of Vegadex for spinach is designed primarily for the overwintering crop. This is being used principally on the Delmarva peninsula and in Arkansas. It is recommended that the second application be made not later than 30 days after emergence of the spinach. The application should be made on clean cultivated soil.

It is becoming increasingly obvious that with good broad-spectrum pre-emergence selectivity, long residual activity has to be sacrificed. This is also the case for vegetable fields that are cropped more than once per season. With this in mind, more emphasis has been placed on a repeat application basis to give season-long weed control. The concept of multiple applications is not new. In previous years such use was hampered by various degrees of toxicity to the foliage. This resulted in only mediocre weed control because significant amounts of the herbicide remained on the foliage and did not reach the soil surface and furthermore contributed to phytotoxicity. Granular formulations may tend to improve the performance of post transplant or lay-by treatments and reduce crop residue problems.

Through the use of Vegadex granules, these problems have been minimized, and weed control is comparable to pre-emergence applications. A lay-by application at time of last cultivation on crops such as tomatoes will also benefit from increased crop competition to decrease subsequent weed development.

It is highly desirable to apply the Vegadex granules directly to the freshly cultivated soil. Under these conditions the granules will lodge among the soil particles in the same pattern as they are distributed. If the granules are applied to cultivated soil which has been compacted by rain, the granules have a tendency to roll to depressions left by the cultivator and results in an uneven distribution particularly if washing rains follow. Since freshly cultivated soil usually is moist, activity of Vegadex is improved.

The residual herbicide activity of Vegadex is generally from 4 to 5 weeks. In the case of applications following last cultivation (lay-by), residual activity is longer because the soil is no longer disturbed, and no new weed seeds are brought to the surface.

It is difficult to outline a specific weed control program for broad usage based on multiple applications since weed problems differ and also grower interpretation of his problem varies. In areas where broadleaves are troublesome, post transplant applications are most effective. Where summer grasses are serious, applications at time of last cultivation are equally, if not more important. The acute weed problems, however, do not always coincide with the time of last cultivation and therefore it is more important that applications of Vegadex be timed with weed development so long as the application does not contribute to residue problems.

Post emergence treatment with granular formulations will require some modification of applicating equipment to suit the particular situation. For a post transplant treatment on tomatoes a 12 to 14" band is adequate but for lay-by applications an 18 to 24" band is more desirable. This would require additional row banding equipment or the use of broadcast equipment modified to deliver the wider band. In some areas, where economics permit, aerial applications can be used.

Application of Vegadex through sprinkler irrigation water presents still another method of application which has been used successfully by several growers where broadcast application is desired. It is usually the practice to apply 1/4" of water followed by the introduction of Vegadex in the next 1/4" of water and flushing the line for 5 to 10 minutes. Preliminary work in New York, Tennessee and California on leaf crops and celery has shown that this method may be applicable for pre-emergence use as well as on established crops where sprinkler irrigation is used. It is however essential that the sprinkler pattern be uniform since overlapping patterns could cause injury. Likewise, "under irrigated" areas would not receive sufficient Vegadex for effective weed control.

Since so many crops and cultural practices are involved, occasionally reports are received where Vegadex causes excessive stand reductions on crops normally believed tolerant. One such instance is turnip greens. Upon investigation by Dr. Campbell[1] of the Development Department, he found that the tolerance was very closely related to depth of seeding. The following table illustrates this:

Yield of Turnip Greens

	Tons per acre	
Rate of Vegadex pounds per acre	Depth of Seeding Shallow*	Deep**
4	2.0	7.0

* broadcast with Brillion seeder

** same type of seeding followed by harrowing and cultipacking

[1]Monsanto Chemical Company, St. Louis, Missouri

Combinations of Vegadex-Randox[1]

Orsenigo (2) reported in 1959 that tank mix combinations of Vegadex and Randox (CDAA) showed promise for use on celery. Ratios of 1:1, 3:2, and 2:3 (totaling 5 pounds per acre) were more effective in weed control, especially of grasses than a 5 pound per acre application of either herbicide alone. Sweet (3) recently reported that a combination of Randox and Vegadex broadens the spectrum of activity with indications of greater crop selectivity. Spinach, tomatoes, broccoli and carrots were included in these trials. Ratios of 1:1 totaling 4 to 6 pounds per acre looked most promising.

Summary

Continued field experience by the grower is opening many avenues of successful uses for Vegadex for control of weeds in vegetable crops. Depending on adaptability and suitability, the applications of Vegadex will include sprays and granules both pre- and post-emergent to the crop.

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[1]Registered trademark of the Monsanto Chemical Company

TRANSLOCATION OF AMITROLE, ATRAZINE, DALAPON AND EPTC IN NORTHERN NUTGRASS

W. F. Donnalley and E. M. Rahn[1]

Abstract[2]

Four chemicals previously found to be active on northern nutgrass were used in this study. They were: amitrole (3-amino-1,2,4-triazole)[3], atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine)[3], dalapon (sodium 2,2-dichloropropionate) and EPTC (ethyl N, N-di-n-propylthiolcarbamate)[3]. The study was undertaken to determine the degree of translocation of these chemicals in nutgrass following soil and foliage applications at varying stages of growth. Autoradiography was employed to study the translocation of radioactive amitrole, atrazine, and EPTC.

Atrazine and EPTC (or a C^{14} labeled degradation product) were readily translocated throughout nutgrass plants following soil applications to 2- and 12-inch plants, but did not enter ungerminated tubers. Similar results were obtained when 2- and 12-inch corn and potato plants treated as above with atrazine and EPTC, respectively. However, both ungerminated corn seeds in atrazine treated soil, and freshly-cut potato seedpieces in EPTC treated soil, absorbed a labeled compound.

Autoradiographs from foliage applications of atrazine and EPTC to 2-inch nutgrass plants indicated that these chemicals were not translocated basipetally; but when atrazine and EPTC were applied to 2-inch corn and potato plants, respectively, there was a slight amount of translocation to the roots. Similar foliage applications of amitrole, atrazine, and EPTC to 12-inch nutgrass plants resulted in a labeled compound being translocated acropetally to a considerable degree for all three chemicals. However, only in the amitrole treated plants was a labeled compound translocated basipetally in appreciable amounts. When atrazine and EPTC were applied to the foliage of 12-inch corn and potato plants, respectively, acropetal movement was considerable, as with nutgrass. Basipetal movement, however, was slight, but more than was the case with nutgrass.

Autoradiographs from foliage applications of amitrole and atrazine to nutgrass plants bearing tubers indicated that a labeled compound was translocated and accumulated in the tubers when amitrole was used, but not when atrazine was used.

In another experiment, amitrole, when applied to the foliage, translocated to the intact tubers and greatly reduced their viability. Dalapon and atrazine applied similarly had little effect on the viability of intact tubers.

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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 C^{14} labeled chemicals: American Cyanamid Co., amitrole; Geigy Chemical Corp., atrazine; and Stauffer Chemical Co., EPTC.

Persistence of Soil-Incorporated EPTC and Other Carbamates 1/

ABSTRACT

L. L. Danielson, W. A. Gentner, and L. L. Jansen 2/

Studies were initiated in 1958 to determine the herbicidal activity of several soil-incorporated carbamate herbicides and to investigate the formulation, soil, and climatological factors involved in their persistence in the soil. Investigations included preliminary and terminal field studies and several greenhouse studies.

1. Field studies of EPTC, CDEC, CIPC, isopropyl N-(3-methylphenyl)-carbamate, BCPC, and CEPC using the logarithmic sprayer indicated that EPTC and CDEC retained their herbicidal characteristics when soil-incorporated at rates of 16 lb/A or less. EPTC was more persistent than CDEC, on the basis of plant bio-assay responses.

2. In greenhouse studies, a soil-incorporated commercial formulation of EPTC dissipated most rapidly under conditions of surface-irrigation and was inversely related to soil organic-matter content.

3. The commercial formulation of EPTC in water was compared to technical EPTC applied in acetone, benzene, xylene, kerosene, and No. 2 fuel oil. Rate of dissipation of EPTC was most rapid when it was applied in kerosene. The persistence characteristics of commercial EPTC in water and technical EPTC in kerosene were confirmed in field studies.

4. Rate of dissipation of soil-incorporated commercial EPTC was accelerated as temperatures increased whereas rate of dissipation of technical EPTC in kerosene was not significantly affected in the present studies.

5. Several concentrations of selected surfactants decreased the rate of dissipation of soil-incorporated technical EPTC formulated in kerosene.

6. These investigations clearly demonstrate that soil-incorporated carbamates differ widely in selectivity and persistence depending on chemical structure, formulation, soil composition, method of irrigation, and temperature. These data have broad implications in the performance of all soil-incorporated carbamates and possibly all herbicides applied in organic solvents. It appears from these data that the period of persistence of soil-incorporated carbamates can be controlled within limits by the constituents used in formulation. These data also suggest the possibility that the period of activity of granular herbicides can be regulated by selection of suitable solvents, surfactants, and granular carriers having specific characteristics.

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1/ Paper submitted for publication in Weeds.

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RELATIVE HERBICIDAL EFFICIENCY OF DACTHAL [1] WETTABLE POWDER AND GRANULAR FORMULATIONS

Paul H. Schuldt [2], L. E. Limpel [2], A. L. Galloway [3], and David Lamont [2]

Abstract

The trend in the last few years toward the widespread use of granular herbicides makes it necessary that new experimental materials like DACTHAL (dimethyl ester of tetrachloroterephthalic acid) be examined as granular preparations along with other more conventional formulations. It is necessary to determine whether granulars increase or decrease herbicidal efficiency, change the residual properties or alter crop tolerance. The physical and chemical properties of a herbicidal candidate dictate or greatly influence what type of formulation will be most successful. It has been demonstrated that granular preparations of one chemical may decrease herbicidal action, while in another, activity may be increased when compared to wettable powders or emulsifiable concentrates. Compounds with low vapor pressures, high melting points, and very low solubility in water are likely to be less effective when formulated as granulars.

The solubility of DACTHAL in water is less than 0.5 p.p.m. and it is sparingly soluble in many organic solvents. It is a white crystalline compound with a low vapor pressure and a melting point of 156° C. Thus, the prospects for a successful granular preparation, particularly for crop use, were not encouraging from either a performance or cost point of view. Therefore, the primary purpose of studies over the last two years was to determine whether a new type of granular formulation would perform satisfactorily compared to a proven wettable powder formulation.

Based on the physical properties of DACTHAL an experimental granular composition and a process were developed which allowed investigation of three variables, i.e. active ingredient, mesh size, and rate of disintegration in water. Active ingredient in the granular preparations varied from 1.25 to 10 per cent DACTHAL (G-1.25, G-1.5, G-5, and G-10). Three ranges in mesh size were tested: 20/40, 30/60, and 40/60. The rate of water disintegration ranged from fast (F) through medium (M) to slow (S). A total of 12 different granular preparations was studied in 15 pre-emergence field tests. In all tests various granular formulations were compared for effectiveness with a 50 per cent wettable powder (W-50). Tests were replicated at least four times in a randomized block design.

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[1] DACTHAL is the trade-mark of the Diamond Alkali Company product, dimethyl ester of tetrachloroterephthalic acid.

[2] Boyce Thompson Institute for Plant Research, Inc., Yonkers, N. Y. Diamond Alkali Company Fellowship.

[3] Diamond Alkali Company, Research Department, Painesville, Ohio.

Plot size varied from 9 sq. ft. to 100 sq. ft. All granulars were applied by hand from a glass jar with a perforated top using the "salt shaker" technique. The sprays were applied with a one-gallon hand pump sprayer equipped with a Teejet nozzle at the rate of 100 gallons of water per acre. The rates used in the various tests ranged from 4 to 20 pounds active chemical per acre.

In 1959 a total of seven experiments was conducted comparing DACTHAL W-50 and G-10(20/40)M granulars on crops and W-50, G-1.25(20/40)M, and G-1.25 (30/60)M granules on turf for the control of crabgrass. The G-1.25 granules were as effective as the W-50 for control of crabgrass in turf. The 10 per cent granulars were significantly less effective than the W-50 in tests for the control of weeds in crops. In a tomato transplant test three G-10M granules with mesh sizes 20/40, 30/60, and 40/60 were compared with the W-50. The performance of the G-10 granulars in this evaluation was much better than in some of the earlier tests, but they were significantly less effective than the W-50. There was not a significant difference between the performance of the various granulars, but the trend was toward greater herbicidal efficiency with the smaller sized granule.

In 1960 eight tests were conducted comparing the W-50 with G-1.5, G-5, and G-10 granules with varying mesh sizes and water disintegrating properties. In tests with transplanted and seeded annual flowers three formulations were ranked in effectiveness for weed control: W-50 > G-1.5(20/40)F > G-5(30/60)F. The G-1.5 granule equalled the W-50 in one test. The G-5 product was significantly less effective in two tests.

In a test on snapbeans where the W-50 and five granulars were compared the weed control obtained with the formulations was in the following order of effectiveness: W-50 = G-5(30/60)F > G-5(20/40)F > G-10(30/60)F = G-10(20/40)F = G-5(20/40)S. The mean weed control percentages based on estimates after 35 days at a dosage of 12 lb. per acre were 91, 91, 81, 74, 72, and 71, respectively. In a test on broccoli significant differences in weed control effectiveness of three formulations were demonstrated in the following decreasing order: W-50, G-5(20/40)F, and G-10(30/60)F. The mean per cent weed control based on estimates after 42 days at a dosage of 8 lb. per acre was 89, 65, and 51, respectively.

The following general conclusions can be drawn from this work: 1. In tests for the control of crabgrass in turf and for control of weeds in annual flowers the G-1.5(20/40)F formulation was as effective as the W-50. 2. The G-5(30/60)F granule in one crop test nearly equalled the performance of the W-50, but was significantly less effective than the W-50 in another test. 3. Herbicidal efficiency of the granulars increased when the per cent active ingredient decreased. 4. Differences in weed control ability due to mesh size and water disintegrating properties within G-5 and G-10 formulations were variable; however, small granules (40/60) combined with fast water disintegration tended to increase herbicidal effectiveness compared to large granules (20/40) with a slow water disintegration rate.

PRELIMINARY STUDIES ON CROP TOLERANCE AND WEED CONTROL WITH A NEW THIOLCARBAMATE HERBICIDE, R-1856[1]

Reed A. Gray, Ralston Curtis, & Joe Antognini

R-1856 (T-butyl di-n-propylthiolcarbamate) has the following structure:

$$\begin{array}{l} CH_3\text{-}CH_2\text{-}CH_2 \\ \qquad\qquad\qquad\quad \rangle N\text{-}\overset{O}{\overset{\|}{C}}\text{-}S\text{-}\underset{CH_3}{\overset{CH_3}{C}}\text{-}CH_3 \\ CH_3\text{-}CH_2\text{-}CH_2 \end{array}$$

The synthesis of R-1856 was reported by Tilles (1) together with a number of thiolcarbamates related to EPTC (Eptam R). The broad spectrum of selectivity of R-1856 was discovered only within recent months. Greenhouse and preliminary field trials reported here, indicate that R-1856 shows promise as a preplant selective herbicide for controlling important annual grass weeds and nutgrass in a number of horticultural and agronomic crops that are susceptible to EPTC injury.

Greenhouse Tests

All greenhouse tests were carried out with R-1856-6E, an emulsifiable concentrate formulation containing 6 pounds of the compound per gallon. In all cases, the herbicide was thoroughly incorporated into the soil (Santa Cruz sandy loam) with a small cement mixer and then the treated soil was placed 3" deep in 8" x 12" metal flats. Weed and crop seeds were planted in rows at various depths and the flats were watered frequently by sprinkling. An excess of water was avoided to prevent leaching.

One of the first tests showed that 5 lbs./acre of R-1856 prevented the emergence of purple nutgrass (Cyperus rotundus) for as long as three months when tubers were planted in the treated soil. Sweet corn (maize) and cotton planted in the same flats were not injured at the 5 lbs./acre rate. At a rate of 20 lbs./acre, no malformation of Golden Emblem sweet corn was observed, while Eptam at 5 lbs./acre injured all the corn plants in the same experiment. Although the germination and emergence of green foxtail (Setaria viridis) was not affected, growth was stopped completely at a height of one inch and within 30 days the plants succumbed, giving 100% control of this weed at the 5 lbs./acre rate.

1. Stauffer Chemical Company, Agricultural Research Laboratory, Mountain View, California.

R) Eptam is Stauffer Chemical Company's registered trade-mark for ethyl di-n-propylthiolcarbamate.

Lower rates of R-1856 were tested on purple nutgrass and it was found that 1 lb./acre prevented the emergence of shoots from tubers for seven weeks. EPTC gave somewhat longer control of purple nutgrass under the same conditions in the greenhouse.

Since R-1856 appeared safe for use on corn, it was tested on Johnson grass (Sorghum halepense) which is a common weed in certain corn growing areas. Twelve Johnson grass rhizomes 3-4" long were planted in each flat along with field corn (Funk 711) and Sudan grass (Sorghum sudanense) seed. At 10 and 20 lbs./acre, R-1856 gave 100% control of the Johnson grass for 3½ months with only slight stunting of the corn plants. At 5 lbs./acre, R-1856 gave 83% control of Johnson grass grown from rhizomes and 100% control of Sudan grass with no injury to corn. EPTC at 5 lbs./acre gave slightly less control of Johnson grass than R-1856 at the same rate and severely injured the corn.

Further tests showed that in addition to nutgrass, Johnson grass and green foxtail, other grass weeds such as smooth crab grass (Digitaria ishaemum), hairy crab grass, (Digitaria sanguinalis), yellow foxtail (Setaria lutescens), barnyard grass or watergrass (Echinochloa crusgalli) and wild oats (Avena fatua) were completely controlled by R-1856 at a 5 lb./acre rate. Smooth crab grass was more susceptible to injury than hairy crab grass. Slightly more than 5 lbs./acre of R-1856 was needed to control annual bluegrass (Poa annua). A higher level of 8-10 lbs./acre of R-1856 was needed to control quack grass (Agropyron repens) from seed.

A number of horticultural crops and a few agronomic crops were tested at various rates and found tolerant to rather high levels of this compound. Rates of 5-10 lbs./acre showed very little or no injury to cucumber, watermelon, squash, cantaloupe, pumpkin, cabbage, broccoli, Brussels sprouts, cauliflower, radish, Chinese cabbage, collards, endive, lettuce, tomato, sugar beet, table beet, carrot, celery, onion, spinach, pepper, sweet corn, field corn, barley, rice, cotton and pineapple. Seven varieties of corn have been tested and all proved to be tolerant to R-1856 at a rate of 10 lbs./acre regardless of depth of seeding.

On the other hand, pea, soybean, small Lima bean, milo, wheat, and several lawn grasses were severely injured by R-1856 at a rate of 5-10 lbs./acre.

Preliminary Field Trials

A limited number of field tests with R-1856 have substantiated the greenhouse findings. Rates of 5 and 10 lbs. of R-1856 in 80 gallons of water per acre were sprayed on dry soil (Sorrento loam) in bands 2' wide and incorporated immediately 3" deep with a power driven tiller. Several rows of crop and weed seeds were then planted ½-1" deep in the treated bands and sweet corn and field corn were planted 3" deep. Immediately after planting and each day thereafter, the plots were watered lightly by overhead sprinkling. R-1856 at 5 lbs./acre gave very good control of green foxtail, barnyard grass, wild oats, Sudan grass and milo. R-1856 at 10 lbs./acre did not injure the deeply planted sweet corn (Golden Bantam) and field corn (Funk 711), nor did it injure cucumbers, tomatoes, carrpts, sugar beets, cotton and red-root pigweed. Peas, however, were injured at a rate of 5 lbs/acre. EPTC at 5 lbs./acre in the same test gave better control of all weeds, but severely injured all of the above mentioned crops. A total of 34% of the corn plants showed severe twisting symptoms in the 5 lb./acre EPTC plots.

Since R-1856 did not control broadleaf weeds in the above test, another small field test was conducted in which a combination of 5 lbs. R-1856 plus 2 lbs. of 2,4-D acid per acre were incorporated 3" deep for weed control in corn. This mixture gave good control of several species of broadleaf and grass weeds without injury to six different varieties of corn planted 3-4" deep.

In another location R-1856 was applied at 5 and 10 lbs./acre and compared with EPTC at 3 and 6 lbs./acre on a silty loam soil in Imperial Valley under high temperature conditions. Immediately after application, the materials were disced into the soil and cotton and cantaloupes were seeded in the treated areas. On the same day and during the first week the plots were sprinkler irrigated, and on the second week the test area was flood irrigated. Results recorded three weeks after treatment showed that R-1856 gave complete control of barnyard grass and red-root pigweed at 10 lbs./acre and almost complete control of both weeds at 5 lbs./acre. The stand and growth of the cotton and cantaloupes were not affected by 5 or 10 lbs./acre of R-1856. Both rates of EPTC (3 and 6 lbs.) gave complete control of barnyard grass, but caused severe damage to the cotton and cantaloupes.

Apparently under certain conditions, R-1856 also controls some broadleaf weeds as shown by the field test just described above. In still another location, good control of purslane (<u>Portulaca oleracea</u>) as well as barnyard grass was observed where R-1856 was used at rates of 4 and 8 lbs./acre.

The field tests showed that the same methods used for applying EPTC were required for R-1856. That is, incorporation immediately (within a few minutes) after application to the soil was necessary to insure maximum herbicidal activity.

Summary

R-1856 is a new thiolcarbamate herbicide (t-butyl di-*n*-propylthiolcarbamate) related to EPTC, which shows promise for controlling nutgrass, Johnson grass and certain annual grass weeds in a wide range of horticultural crops and several agronomic crops. The weeds that were controlled and the crops that showed considerable tolerance to R-1856 when incorporated preplant in

greenhouse tests are listed below. An (F) preceding the weed or crop indicates that field results have confirmed greenhouse results.

1. <u>Annual Grasses Controlled With 3-5 lbs. R-1856 Per Acre</u>

(F) Green foxtail (*Setaria viridis*)
Yellow foxtail (*Setaria lutescens*)
Smooth crab grass (*Digitaria ishaemum*)
Hairy crab grass (*Digitaria sanguinalis*)
(F) Barnyard grass (*Echinochloa crusgalli*)
(F) Wild oat (*Avena fatua*)
Annual bluegrass (*Poa annua*)
(F) Sudan grass (*Sorghum sudanense*)

2. <u>Perennial Weeds Controlled With 5-10 lbs. R-1856 Per Acre</u>

Johnson grass (*Sorghum halepense*)(from rhizomes and seed)
(F) Purple nutgrass (*Cyperus rotundus*) (from tubers)
Quack grass (*Agropyron repens*) (from seed)

3. <u>Crops Tolerant to 5-10 lbs. R-1856 Per Acre</u>

(F) Cucumber
(F) Cantaloupe
Watermelon
Squash
Pumpkin
Cabbage
Broccoli
Brussels sprouts
Chinese cabbage
Cauliflower
Collards
Radish
Endive
Lettuce
(F) Tomato
Pepper
Spinach
(F) Carrot
Celery
Onion
Table beet
(F) Sweet corn (Maize)
(F) Field corn (Maize)
(F) Cotton
(F) Sugar beets
Pineapple
Barley
Rice

4. <u>Crops Injured by 5-10 lbs. R-1856 Per Acre</u>

Pea
Soybean
Lima bean
Lawn grasses
Milo
Oat
Wheat

Literature Cited

1. Tilles, Harry, Thiolcarbamates, Preparation and Molar Refractions. Jour. Amer. Chem. Soc. 81:714, 1959.

EPTAM FOR NUTGRASS CONTROL IN POTATOES

E. M. Rahn and W. F. Donnalley[1]

Abstract

Eptam (ethyl N, N-di-n-propylthiolcarbamate) was evaluated for control of northern nutgrass (Cyperus esculentus L.) in potatoes in 1958, 1959, and 1960. This herbicide was applied at varying times and rates, as a spray and in granules, and with and without soil-incorporation.

As for time of application, control was good with application either just before planting or just after drag-off. In 1960, when nutgrass infestation was particularly heavy, the before planting application was slightly more effective. Split-applications, i.e., just after drag-off and just before the last cultivation, were not significantly better than single applications either just before planting or just after drag-off.

As for rate of application, 6 lb/A was slightly better than 4 lb/A, especially when applied just after drag-off.

Sprays and granulars were equally effective in over-all applications made just prior to the last cultivation.

All Eptam applications were incorporated with the soil except in 1958. In that year, when the herbicide was applied at 5 and 10 lb/A five days after planting to soil compacted by 3/4 inches of rain, control of nutgrass was poor. However, when the same rates were applied just after drag-off to loose, freshly-cultivated soil, control of nutgrass was good.

None of the Eptam treatments had any harmful effects to potatoes with regard to emergence, plant vigor, yields, or percent dry matter in tubers.

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PROGRESS REPORT ON LAY-BY WEED CONTROL IN POTATOES

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ABSTRACT

Annual grasses, particularly crabgrass and barnyard grass, are a problem in potato production after the last cultivation. These grasses do not necessarily reduce yields but are troublesome at harvest. There has been a search for herbicides that would effectively control these grasses and other weeds from lay-by to early fall when potatoes are harvested. Many have been either ineffective or have reduced potato yields. The object of this study was to evaluate some of the newer herbicides for weed control after lay-by.

After the last cultivation the following herbicides were applied: ethyl N,N-di-n-propylthiolcarbamate (EPTC), n-propyl di-n-propylthiolcarbamate (R-1607), ethyl ethyl-n-butylthiolcarbamate (R-2060), and propyl ethyl-n-butylthiolcarbamate (R-2061) at 4 and 6 lb./A of a 5% granular formulation and 6 lb/A of the emulsifiable concentrate; 3-amino-2,5-dichlorobenzoic acid (amiben, 5% granular), tris (2,4-dichlorophenoxyethyl) phosphite (falone, 10% granular) and N-1 naphthylphthalamic acid, sodium salt (NPA, 10% granular) at 4 lb./A; dimethyl 2,3,5,6-tetrachloroteraphthalate (dacthal, 5% granular) at 6 and 12 lb/A; and Hercules 7442 (H-7442, 5% granular) at 2, 4, and 6 lb./A.

Almost complete weed control was obtained with amiben and the high rate of granular R-1607. Other effective treatments included the high rates of granular R-2061 and EPTC. The liquid formulations of all the thiolcarbamates were ineffective. Notwithstanding that some of the other herbicides showed promise they were ineffective for weed control at the rates used in this study.

No treatment significantly increased or reduced yields of potatoes from the control.

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Progress Report On Potato Vine Killing

R. L. Sawyer and S. L. Dallyn[1]

This report is a continuation of the work covered in previous proceedings on finding potato vine killing methods which would simulate normal potato maturity.

Materials and Methods: Sodium silicate at 0, 2, 4, 6, and 8 gallons per acre was added to sodium arsenite at 0, 2, 4, 6 and 8 pounds per acre. Plots were three rows wide and 30 feet long with 4 replications. Katahdin potatoes were planted April 16. Materials were applied on August 8 before vines had started to go down, but after a good yield of tubers was under the vines. Materials were rated 0 through 10 for speed of kill five times in the next three weeks with 0 giving normal foliage, 5 complete leaf kill and 10 both leaf and stem kill. The rating given in the table is an average for the five readings. At harvest, on September 8, tubers were rated for degree of skinning, 1 through 10 with 1 indicating no skinning and 10 severe skinning. Ratings of 7 and above were reserved for samples where skinning would detract from grade. Tubers had passed over a roll grader before rating.

Results and Discussion: These results clearly indicate that the fast kill of sodium arsenite is hurting both internal quality and exterior quality of potatoes. Although the results are not as great as in 1959, sodium silicate tends to counteract the detrimental effects of sodium arsenite at the dosages necessary for adequate vine kill.

As in the previous year sodium silicate slowed down the action of sodium arsenite. This was most apparent at the high dosages of sodium arsenite. The specific gravities tended to be best at the high dosages of sodium silicate. Skinning tended to be least at the high dosages of sodium silicate. The specific gravity decreased as the dosage of sodium arsenite was increased. Skinning was least where potatoes had no sodium arsenite or at the low dosage of sodium arsenite. The potatoe vines in these plots had gone to normal maturity. The materials were applied early enough so that high dosages of sodium arsenite decreased yields.

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Paper No. 447, Department of Vegetable Crops, Cornell University, Ithaca, N. Y.

Table 1. Effect of sodium silicate added to sodium arsenite on potato vine killing.

Sodium Arsenite	Sodium Silicate	U. S. No. 1's Bu./Acre	Specific Gravity	Skinning Index	Maturity
0	0	698	1.0627	6.0	.2
0	2	670	1.0620	4.7	.1
0	4	696	1.0647	5.7	.3
0	6	683	1.0630	7.0	0.0
0	8	687	1.0624	5.2	.5
2	0	626	1.0600	6.0	2.2
2	2	654	1.0602	5.0	.5
2	4	634	1.0610	3.5	2.2
2	6	668	1.0612	4.2	.7
2	8	715	1.0635	4.0	1.3
4	0	624	1.0595	4.2	3.7
4	2	602	1.0587	2.2	3.5
4	4	617	1.0590	3.0	4.4
4	6	641	1.0587	5.5	2.5
4	8	624	1.0612	3.2	2.5
6	0	594	1.0597	4.0	6.1
6	2	600	1.0602	4.5	4.0
6	4	609	1.0615	3.0	4.2
6	6	604	1.0595	5.2	3.4
6	8	636	1.0600	5.7	3.0
8.	0	581	1.0575	3.5	5.9
8	2	636	1.0590	3.7	3.4
8	4	621	1.0600	4.2	2.9
8	6	600	1.0587	3.0	3.5
8	8	641	1.0615	3.5	3.8

Source	DF	Mean Squares			
Replications	3	195.69	14.33	2.33	164.67
Sodium Arsenite	4	307.74	61.00	15.50	1482.50
Sodium Silicate	4	50.47	13.25	4.50	212.50
S.A. x S.S.	16	110.84	3.69	3.50	50.81
Error	94	10.44	5.01	1.14	11.87

FACTORS INFLUENCING THE PERFORMANCE OF CDEC[1/]

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Although CDEC* (2-chloroallyl diethyldithiocarbamate) has found considerable usage on vegetable crops in Eastern United States, it has not reached its full potential as a selective herbicide because of its erratic performance. CDEC sometimes fails to control weeds, and in certain situations may injure the crop. For best performance it is generally agreed that CDEC should be applied at planting and that irrigation should be given if rain does not occur soon after treating. In spite of these precautions, the performance of CDEC under field conditions has been variable. The purpose of these investigations was to determine more specifically the factors influencing CDEC activity under field conditions in order to avoid failures due to either crop injury or lack of weed kill.

Review of Literature

The activity of herbicides applied to the soil are known to be influenced by many environmental and soil factors. Obtaining commercially acceptable weed control without crop injury from the proper dosage of a presumably selective soil herbicide is a function of the total influence of environment and soil on the herbicide, on the weeds, and on the crop. The influencing factors most often mentioned in connection with the activity of CDEC are rainfall, soil type, and timing. Temperature and formulation are also cited.

Danielson (1957) stated that CDEC performed poorly with low soil moisture. Irrigating greatly enhanced weed control. However, delayed applications following rains were poor. He concluded the optimum procedure was to apply at time of seeding, and to irrigate if rains were not soon forthcoming. He did not suggest reasons for the variable performance of CDEC under variations in soil moisture conditions. It was further suggested that somewhat higher rates were needed in summer than in the cooler time of the year. He also studied formulations and reported that dry granular carriers such as vermiculite and attaclay were as effective as liquid formulations.

Otten (1957) reported on the persistence and movement of CDEC in soils. He stated that both temperature and moisture were important factors influencing the loss of activity. His results also clearly showed that although CDEC could be leached, it was rather difficult to move appreciable quantities downward from surface applications. This was true even with two inches of water on a Dunkirk sand which contained less than 1% organic matter and less than 4% clay and silt combined. However, more CDEC was leached with a given amount of water, if the chemical was added to a wet soil rather than to a dry soil. He concluded that microbial action was important in rapid loss of activity of CDEC under field conditions.

1/ Paper No. 451 of Department of Vegetable Crops.
* Sold as Vegadex by Monsanto Chemical Co.

Sheets (1959) studied under laboratory conditions the influence of soil type on the activity of CDEC. He was particularly concerned with organic and clay content, cation exchange capacity and pH. There was no clear cut influence of any of these characteristics on the activity of CDEC as measured by toxicity to oats. Using rates of CDEC roughly ten fold that of field applications, he found that with warm, moist conditions all levels of CDEC were rendered relatively innocuous within three months.

Gantz and Slife (1960) confirmed the findings of Otten (1957) regarding the relative lack of leaching of CDEC with rainfall. These workers studied the persistence of CDEC under moist and dry soil conditions at temperatures of 40°, 60°, 80°, and 100°F. They found little loss of activity under either moist or dry soil conditions with the 40° and 60° treatments. Initial activity was the same for wet and dry soils, regardless of temperature. There was no difference in the activity of CDEC in the moist or dry soils at the higher temperatures except in the first two weeks. At this time, a much higher level of activity was noted under moist conditions. These findings are at variance with those of Otten (1957) who found practically complete loss of CDEC activity at 82°F in about five days in moist soil.

Monsanto (1959) reports that volatility may be an important factor influencing activity of CDEC. Vapor pressure of CDEC is stated to be 2.2×10^{-3} mm of Hg at 20°C. Water has a V.P. of 17 mm of Hg at 20°C. It was calculated that in the absence of other forces such as physical or chemical adsorbtion, CDEC would evaporate in less than eight hours at temperatures as low as 45°F. An experiment was also reported in which CDEC and CDAA were applied to dry soil surfaces and some treatments were covered with 1/4" of soil immediately after treating. This soil covering greatly increased Randox activity. Only at very low rates, one pound or less, could a similar trend be noted for CDEC. Peculiarly, when samples were watered immediately after treating, which, presumably, drastically reduced volatility opportunity, the same general beneficial results from covering CDAA were noted. This is highly suggestive that factors other than straight volatility must be involved. Since the vapor pressures of CDAA and CDEC are of the same order of magnitude (when activity is considered after a period of a week) it was to be expected that the performance of both herbicides would be about the same. However, CDEC was distinctly less influenced by the shallow soil covering than was CDAA. This also suggests that volatility per se is a questionable factor influencing CDEC activity.

Havis (1959) reported that eight pounds of CDEC applied to a dry soil surface and then either incorporated by stirring with a shallow cultivator or applying one inch of water gave very good weed control. Applying CDEC to a wet soil was less satisfactory. Stirring the wet soil decreased the activity. No suggestion was made as to the possible reasons for CDEC variable performance dependent on soil moisture conditions or mechanical incorporation.

Sweet (1960) reported that incorporation of CDEC enhanced weed control and greatly increased damage to red beets. He also showed that damage to seeded crops under field and greenhouse conditions could be readily correlated with high temperatures, at or shortly after time of application. No explanation was suggested for this striking effect of temperature and no specific level of temperature was considered the threshold between safe usage and crop injury. Formulations were included in these studies. No correlation could be noted between liquid and granular carriers and crop injury.

Experimental

Studies of factors influencing CDEC activity after application

In 1960 a series of field experiments were designed to study the influence of depth and method of incorporation, irrigation, formulation and timing, on the activity of Vegadex. All tests were conducted on a sandy loam soil. Test "weeds" timothy and rye grass were seeded to supplement the natural population potentially heavy in lamb's quarters.

In the first test the field was plowed July 1 following a spring crop which had somewhat depleted the soil moisture. Two days later it was fitted first by disking and then by a meeker harrow which gave a fine seed bed. Timothy and rye grass were seeded and lightly "meekered" to give very shallow seed coverage. The entire area, except for four plots, was treated with CDEC at four pounds an acre. One-half of each plot received a liquid formulation, the other half a clay granular formulation.

To determine the influence of method and depth of incorporation, certain plots received one-half inch of water and others one and one-half inches of water from sprinkler irrigation. Comparable plots were raked lightly and others cultivated by means of a hand wheel hoe fitted with teeth that stirred the soil to a depth of from one and one-half to two inches.

Timing was studied by giving the mechanical incorporation and the sprinkler watering treatments at different intervals in relation to time of application of CDEC. Four plots received the CDEC during the course of the irrigation treatments. Four plots were mechanically stirred and four watered immediately following CDEC application. Eight plots were given comparable treatments about 20 hours later. A final series was treated 72 hours after CDEC application.

The smallest plots were 4 x 10. These were paired side by side to study formulation. A three foot buffer separated each 8 x 10 area. There were two CDEC treated plots which received no mechanical stirring or watering until the entire area was irrigated or rain occurred. There were two replications.

During the treatment period for the first test, the temperature was abnormally cold (see Table 1.). The sky was generally overcast and winds were relatively brisk. Five days following initial seeding and treating, the entire area including all previously treated plots were irrigated with about one and one-half inches of water.

A duplicate experiment was started August 16th on the same soil type.

Treatments were identical to those in the first test except for the four plots which were treated during irrigation. In this second test the liquid CDEC was applied by means of a hose-proportioner during the first one-quarter inch of irrigation, instead of interrupting the irrigation temporarily after one-quarter inch had been applied.

Although moisture determinations were not made, it appeared that in the second experiment soil moisture was definitely better than during the first test. As can be seen from Table 1, temperature conditions were very much different. During the treating period midday maximum temperatures were considerably higher. On August 19th rain occurred, which brought all plots to a level satisfactory for seed germination.

A third test in this series was started August 27th. In this test the number of treatments was greatly reduced. No mechanical incorporation was included. Only the one-half inch rate of irrigation was given. An additional important change in treatments was to increase the interval between the time of applying CDEC and the times of watering. These four times of treatment were: 1) during; 2) immediately following; 3) two days; and 4) one week following. Also, an additional formulation, CDEC on vermiculite, was added. Thus each major 12 x 10 plot consisted of three formulations.

Table 1. Temperature and rainfall during treatment periods for the CDEC incorporation, irrigation and formulation tests.

Days After CDEC Appl.**	Test No.1 July 4 °F. Max.	Min.	Precip.	Test No.2 August 16 °F. Max.	Min.	Precip.	Test No.3 August 27 °F Max.	Min.	Precip.
0	69	48	.0	77	49	.0	82	57	.0
1	69	48	.0	82	54	.0	88	49	.0
2	73	46	.0	85	53	.0	88	54	.0
3	74	44	.0	75	54	.68	81	58	.0
4	79	45	.0	77	58	.12	83	59	.0
5	85	57	1.5*	82	61	.03	86	64	.0
6	84	60	.0	80	62	T	72	49	.0
7	83	56	.0	71	57	.03	70	43	.0
8	87	56	.0	70	44	.0	71	61	.51

* Overhead irrigation.
** No treatments applied after three days in tests one and two, after seven dayis in test number three.

In this test soil and temperature conditions were considerably different from those in the previous two tests. Soil moisture to plow depth was so seriously depleted that no seed activity could be noted until after irrigation of the various plots, or until the general rain which came eight days after starting the test.

Results of the three tests were recorded by rating "weed populations". In the first test the prevalent species were the two seeded grasses and crabgrass. In the second test lamb's quarters was predominant in most plots. In the final test of this series the seeded grasses, timothy and ryegrass, were prevalent. The data are presented in Tables 2 and 3 and Figure 1.

It is apparent from Table 3 that in test one mechanical incorporation was inferior to water as a means of enhancing the effectiveness of CDEC. Generally speaking, cultivating was more detrimental than raking. No definite statement can be made as to why the incorporation treatments should be inferior regardless of timing or formulation of CDEC. It is suggested that incorporation may have placed the CDEC in a position favoring some microbial breakdown or fixation by the soil.

The influence of water is not clear cut. Moisture levels below the surface were moderately dry, satisfactory, and very dry for tests one, two, and three respectively. No weed or crop seed activity could be noted in tests one and three until after water was applied. It is interesting to note that the poorest control of weeds was observed in the check plots of test two (see Table 2 and Figure 1). Here, weed activity was present without additional moisture being added. In the three tests moisture was added to the checks, five, three, eight days respectively after CDEC. In test No. 2, rain occurred after only three days. In spite of this relatively short period, weed control was definitely inferior to that of the plots watered earlier in this test.

Table No. 2. Weed control under various treatments following application of CDEC at four pounds.

Treatment and when given after CDEC Appl.		Weed Ratings 1/ No. 1	No. 2	No. 3
1. 1/2" H_2O	0 during irrigation	5.5	5.0	6.0
2. 1 1/2" H_2O	"	5.75	5.5	-
3. 1/2" "	0 immediately after	6.0	5.0	7.0
4. 1 1/2" "	"	6.5	7.0	-
5. 1/2" raked	"	5.5	5.5	-
6. 1 1/2" cultivated	"	4.75	5.0	-
7. 1/2" H_2O	1 day	6.0	4.0	**6.0
8. 1 1/2" "	"	6.0	5.0	-
9. 1/2" Raked	"	5.75	4.0	-
10. 1 1/2" cultivated	"	4.5	4.0	-
11. 1/2" H_2O	3 days	6.5	5.0	-
12. 1 1/2" "	"	6.5	4.5	-
13. 1/2" raked	"	5.0	5.0	-
14. 1 1/2" cultivated	"	4.75	5.0	-
15. Check*		5.50	3.5	7.0
16. 1/2" H_2O	7 days	-	-	7.0

1/ A rating of 9 = no weeds; 7 = 20%; 5 = 50%; 3 = 70% ground cover. Ratings are an average of four plots for Test 1 and 2, and six plots for Test 3.

** In this test water applied 2 days after CDEC.

* Water was added to the check plots after 5, 3 and 8 days for Tests 1, 2, and 3 respectively.

Grassy weeds predominated in tests 1 and 3; lamb's quarters in test 2.

Figure 1. Relative performance of liquid and granular CDEC formulations in two tests under different treatments following application.

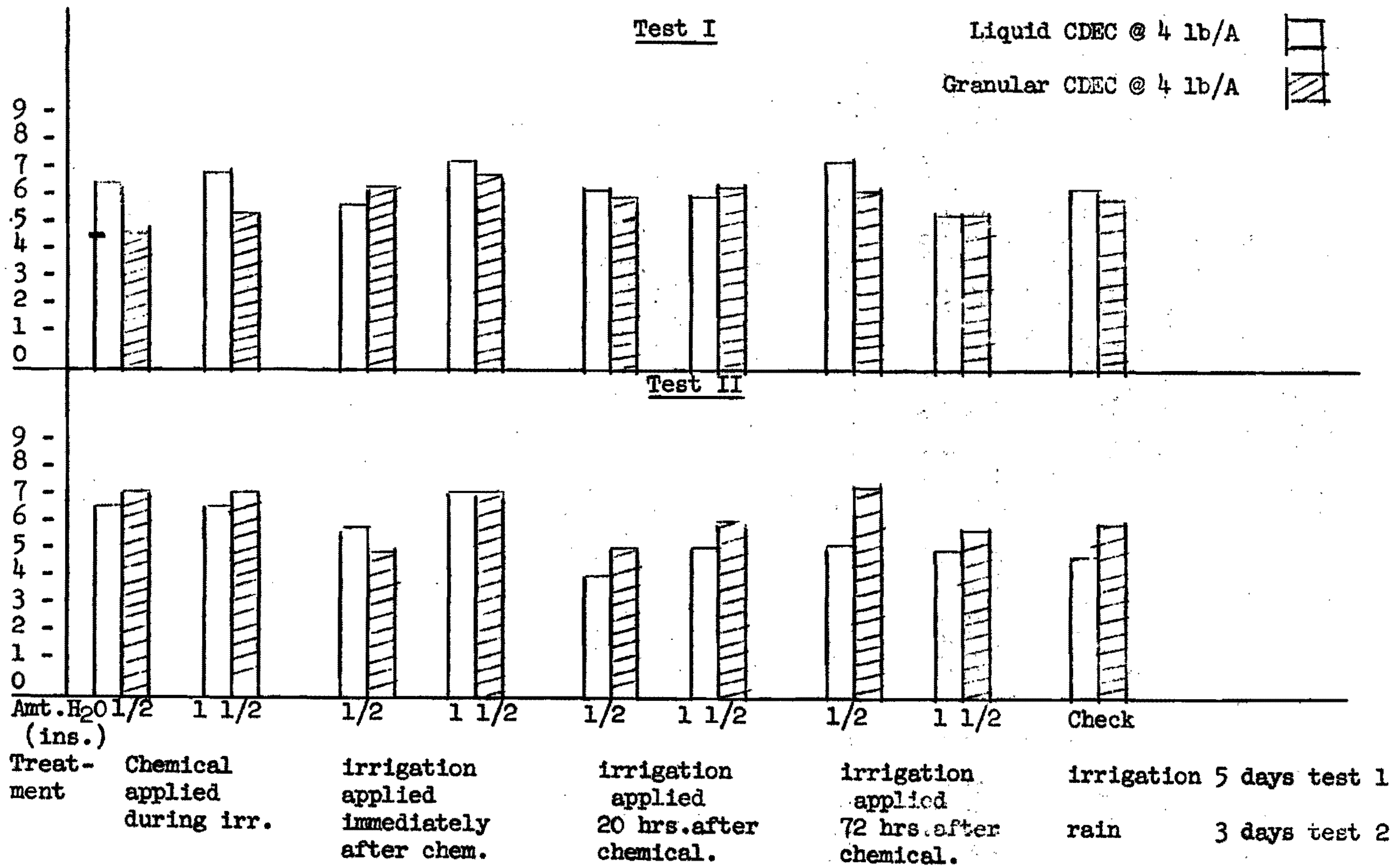

Table 3. A comparison between watering and mechanical incorporation at intervals following CDEC applications. The data are weed control ratings. [1]

Test No. 1

	H_2O		Mechanical	
Days	1/2 in.	1 1/2 in.	1/2 in.	1 1/2 in.
0	6.0	6.5	5.5	4.75
1	6.0	6.0	5.75	4.5
3	6.5	6.5	5.0	4.75

Test No. 2

	H_2O		Mechanical	
Days	1/2 in.	1 1/2 in.	1/2 in.	1 1/2 in.
0	5.0	7.0	5.5	5.0
1	4.0	5.0	4.0	4.0
3	5.0	4.5	5.0	5.0

[1] The higher the number the better the control of weeds.

Another interesting point that shows clearly is that in test two, the higher level of water application was definitely superior to the lower level in all times of application except the last, which was three days after CDEC or, the same as the checks. It is to be noted that 3-day plots received 0.68 inches of rain in addition to the amount listed in the Table. On this basis the same general trend holds, that higher rainfall gave better weed control.

Although results with formulations were slightly different in each of the three tests, no consistent differences were evident.

Studies on the influence of time of CDEC application in relation to crop seed development.

The literature contains little information on the relationship between time of CDEC application to crop tolerance. Two tests were conducted in an attempt to determine the possible influence of time of CDEC application on crop and weed response. In the first test, August 11, a small area was plowed, fitted, and marked off into eight plots 6' x 15'. Two rows each of beets, spinach, and broccoli, were seeded at once across each plot. Timothy was broadcast over the entire area. Two plots were sprayed with four pounds of CDEC immediately after seeding. At two, four, and six days after seeding, additional plots were treated. On August 12 between the first and second treating period about two-thirds of an inch of rain fell. The remainder of the treating period was dry.

The ultimate stand of crops was erratic. Also, there was variability between replications. Therefore, precise ratings are not presented. However, a trend was apparent which showed more damage to crops from the four-and six-day treatments than from the earlier two treatment times.

A duplicate test was started August 11. This location with a similar sandy loam soil had very good uniformity. The weather, however, was much different. Irrigation was supplied after the first treatment. Light showery weather prevailed for the next week. Moisture at the surface was almost continuously good for seed germination. However, no substantial rainfall occurred. By the time of the six-day-treatment all crops seedings had emerged. In Table 4 are presented the crop and weed control ratings taken three weeks following the first treatment. The data show a striking picture of increased injury at the time of crop sprouting and less damage at the sixth day when the crop had just emerged. The same general trend but much less pronounced was evident in weed control. These results strongly suggest that activity of CDEC in relation to crops frequently considered "tolerant" is definitely influenced by time of application. Furthermore, that activity on weeds species is perhaps increased when the seeds are sprouting.

Table 4. The influence of time of CDEC application in relation to date of crop seeding.

4 lbs. of CDEC	Crops* Beets	Spinach	Broccoli*	Weeds1/
0 days	8.00	8.25	7.5	6.0
2 "	7.75	6.25	7.5	7.0
4 "	3.50	3.75	4.5	7.5
6 "	6.75	5.50	6.5	6.0
Check	8.0	7.00	7.5	2.2

1/ Check plots contained high populations of purslane, crabgrass and galinsoga.
* Ratings of crops are an average of four values for each observation except for broccoli, which is for two values. 9 = perfect growth; 7 = slight stunting but commercially acceptable; 3 = severe stunting and reduced stand; 1 = complete kill.

Weed control ratings: 9 = 100% control; 5 = substantial weeding needed for commercial control; 1 = complete heavy ground cover.

Discussion

In the tests reported here there were several observations that need critical evaluation and interpretation. Results with formulation were somewhat variable but were definitely not an important factor influencing overall CDEC performance.

Mechanical incorporation was inferior to irrigation as a means of enhancing CDEC activity when the soil was fairly dry. However, under conditions as in test two, where underneath the surface, seed germination occurred without additional water, mechanical was generally as good as watering. An important exception was the superior results obtained with the higher rate of water immediately after applying CDEC. No definite statement can be made on the reasons for these results. One possibility is that mechanical incorporation resulted in a somewhat deeper penetration of the herbicide than did irrigation, and this resulted in either some additional microbial action or soil fixation. The fact that the differences were greater in drier soil favors the soil fixation theory.

The influence of moisture was not clear cut. In the second test, where the surface was dry, but the lower depths had reasonably adequate moisture, the heavier rates of water were definitely superior to the lower water rates in the early applications. In the third test, however, one-half inch of water on a soil extremely dry throughout the plow depth gave satisfactory weed control. If leaching of the chemical were an important factor then according to Otten (1957) there should have been substantially more CDEC moved into somewhat lower levels and adequate control should have been obtained with both moisture levels in test two since it was basically more moist.

If volatility were a factor, test three should have yielded poor results when water was delayed for seven or eight days in which temperatures reached the high 80's. Here, however, the eight day "checks" gave as good weed control as did any plots of the experiment watered earlier, or for that matter, control equal to that of the best plots in any of the three tests. There is some suggestion from field observations that increased volatility from a moist soil as compared to a dry soil may be a factor in a shortened period of CDEC effectiveness. The authors believe, however, that a much more logical explanation would be that substantial breakdown by microbial activity occurs under moist conditions.

Failure of CDEC to control weeds under practical field conditions can hardly be entirely explained either on the basis of volatility, or because of microbial breakdown. In actual practise, soil surfaces are frequently very dry within a few hours of seeding and treating. There is little likelihood of microbial action being at a high level on a dry soil surface. Furthermore, it has often been observed that when the soil surface remains moist for several days following CDEC applications, weed control is likely to be excellent. Yet it is these precise conditions which have been suggested by many as greatly increasing the losses of CDEC from both volatility and microbial action.

It was clearly evident in the tests reported here that whether the soil surface was dry or wet during or soon after treating was not the sole factor influencing results. A much more important factor was the status of the soil moisture beneath the surface and its influence on the crop and weed seeds. In tests one and three, where soil moisture was generally low, seed activity was slight until the plots received water. In test two, however, seed activity was good without additional water. Here a delay of three days in adding water substantially reduced the effectiveness of CDEC. At first glance, this fact may appear to support the microbial breakdown theory, but it should be remembered that the check plots were extremely dry at the surface from time of applying CDEC until rain occurred. It is suggested that in this three day period substantial progress in germination had been made by the seeds and that the .68 inches of rain which occurred after three days was insufficient to leach toxic quantities of CDEC down into the germination zone. Further evidence of this can be seen in Table 2 where the three day watered plots which also received the rainfall gave substantially the same weed control as did those with the earlier waterings.

The two tests which dealt with time of applying CDEC in relation to crop seeding further substantiate the authors contention that the actual situation regarding seed development at the time of CDEC "contact" is an important consideration often overlooked. It is believed that this critical factor may account for the injury reported from CDEC at high temperatures and from more frequent cases of injury on muck as compared to mineral soils. In both instances if CDEC is applied at planting, there is much greater likelihood of more rapid germination and, consequently, a greater chance of CDEC contacting the crop seeds in a critical stage of germination. The data in Table 4 illustrate conclusively that crop and weed seeds are both susceptible during sprouting and quickly become less susceptible to surface applications as the plumule and hypocotyl develop. Linder (1954) working under laboratory conditions, concluded that the stage of seedling development most susceptible to carbamate injury was that when the seed coat had just been penetrated by the radicle.

It is suggested by the authors that the controlling factor in determining CDEC activity under practical field conditions is to have CDEC present at the actual zone of seed germination when the radicle is emerging. Practically all of the apparent contradictions in these tests and those discussed above can be resolved on this basis.

Summary and Conclusions

Three factorial experiments were conducted on a sandy loam soil involving watering, mechanical incorporation, formulation, and timing as possible field factors influencing CDEC activity. Two tests were conducted in which CDEC was applied at two day intervals following seeding. By correlating such factors as temperature and soil moisture with treatments given and measuring weed and crop response, and by interpreting the work of other investigators, the authors attempted to evaluate the various factors possibly influencing CDEC activity.

The following points were fairly evident from the data presented:

1. Volatility from either a dry or moist soil surface was unimportant in determining CDEC effectiveness.

2. Formulations on dry granular clay or vermiculite performed as well as the conventional liquid formulation.

3. Leaching was relatively unimportant. However, 1 1/2 inches of water gave better results than 1/2 inch when weed seeds were sprouting at the time of CDEC application.

4. Soil fixation probably plays a minor direct role in determining activity of CDEC. However, coupled with low solubility, this results in very little movement in the soil. Lack of appreciable movement may enhance or diminish weed control in the field depending on many factors.

5. Microbial activity probably had little to do with CDEC failures, but

undoubtedly is the major method by which the herbicide is removed from the soil after a period of several weeks.

6. Timing the application was extremely important. Delayed applications made at the time of crop seed sprouting caused severe stand reductions and stunting of surviving plants.

Delayed applications if made subsequent to substantial weed-seed radicle growth or seedling emergence will result in almost complete lack of control.

7. Either mechanical incorporation or watering immediately after application enhanced the effectiveness of CDEC.

8. The authors believe the key to success with CDEC is to have ample active chemical at the actual zone of seed germination when the radicles are just emerging from the seed coat. This will give excellent weed control regardless of any other known soil or environmental factor.

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CONTROL OF WEEDS IN VEGETABLE CROPS WITH A SUBSTITUTED DIPHENYLACETAMIDE

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Introduction

Extensive studies in the greenhouse and field have been conducted on a large number of substituted diphenylacetonitriles and diphenylacetamides. Special attention has been given to a new selective herbicide, N,N-dimethyl-α,α-diphenylacetamide. This compound was coded as L-34314 and now bears the tentative generic name diphenamid.

In greenhouse tests diphenamid gave good pre-emergent activity against all seedling grasses tested and against broadleaf weeds such as pigweed and smartweed at rates of 4 lb/A. A number of important horticultural and agronomic crops were tolerant to the material. Structure-activity studies revealed that lengthening the chain of the alkyl substituents of the amide portion of diphenamid resulted in reduced activity.

Field Tests

The promising greenhouse results with diphenamid led to its inclusion in thirteen field tests on a total of 28 different crops. Major emphasis has been on tomatoes, other vegetable crops, and forage legumes.

Diphenamid has a rather low solubility in water (260 ppm) and in most organic solvents. It was, therefore, formulated as a wettable powder and on clay granules. Applications of the wettable powder formulation were made with a small plot sulky spray rig. Granules were applied with a lawn spreader. Slightly better results were generally obtained with the wettable powder formulation. All field tests were replicated and of a randomized block design.

<u>Tomatoes</u> -- Four pre-emergence field tests were conducted on tomatoes; three with field-seeded tomatoes, one with tomato transplants. In all tests, 4 to 6 lb/A of diphenamid gave satisfactory control of weed grasses with no damage to tomatoes. Table 1

1/ Eli Lilly and Co., Agricultural Research Center, Greenfield, Indiana

gives an average of data from the four tests. The treatments in each test were replicated four times, and the weed control averages were based on average quadrat counts of the four replicates in each experiment.

TABLE 1. SUMMARY OF GRASS WEED CONTROL AND TOMATO INJURY

Diphenamid Lb/A	Average Percent Control Grass Weeds 1/	Average Injury Rating 2/ Tomatoes
2	54	1.0
4	88	1.1
6	92	1.2
8	96	1.7

1/ Four weeks after treatment

2/ Injury Rating Scale: 1 = no injury, 2 = slight, 3 = moderate, 4 = severe, 5 = death of plant

Broadleaf weed control was generally poorer than grass weed control, due chiefly to the occasional presence in the plots of Jimsonweed and ragweed, two species not controlled by diphenamid. Pigweed, however, was satisfactorily controlled in all trials at 6 lb/A. Tomato yield data were collected in two tests. There was no depression in weight of ripe fruit at harvest and, in fact, non-significant increases in yields were obtained at the 4, 6, and 8 lb/A rates.

Other Vegetable Crops -- Excellent results were obtained with diphenamid in two vegetable crop tests. Table 2 gives the results of one of these tests and Table 3 presents the responses of the crops tested to diphenamid.

TABLE 2. THE EFFECT OF DIPHENAMID ON GRASS AND BROADLEAF WEEDS IN VEGETABLE CROPS

Rate Lb/A	Average No. Weeds/Sq. Ft 1/		Average Percent Control 1/	
	Grasses	Broadleaves	Grasses	Broadleaves
0	41.7	17.3	--	--
2	0.8	1.9	98	89
4	0.4	2.1	99	88
6	0	0.7	100	96
8	0	0.7	100	96

1/ All counts made five weeks after treatment. Grass weeds were barnyard grass, foxtail, and goosegrass. The dominant broadleaf weed was primarily pigweed.

TABLE 3. RESPONSE OF VEGETABLE CROP SPECIES TO 8 LB/A OF DIPHENAMID

Tolerant		Moderately Tolerant	Susceptible
Green Peppers	Turnips	Cucumbers	Red Beets
Lima Beans	Radishes	Cabbage	Spinach
Peas	Mustard	Carrots	Cantaloupe

Forage Legumes -- Alfalfa, red clover, crimson clover, Dutch white clover, Ladino clover, birdsfoot trefoil, and Korean lespedeza were the crop plants included in three pre-emergence field tests of diphenamid on forage legumes. Severe damage to the clovers occurred at rates as low as 2 lb/A. Alfalfa, birdsfoot trefoil, and Korean lespedeza were tolerant of 4 to 6 lb/A rates. Grass weed control was good at 4 lb/A. Pigweed and lambsquarters were killed at 4 to 6 lb/A. Incorporation of diphenamid into the soil did not improve activity over surface application.

Field Crops -- Two field crop experiments were conducted in which diphenamid was applied at 2, 4, and 8 lb/A. The field crops were alfalfa, soybeans, snapbeans, corn, sorghum, oats, sugar beets, and cotton. Of these, alfalfa, soybeans, snapbeans, sorghum, and cotton were tolerant to diphenamid at rates through 8 lb/A. Good grass weed control was obtained at 4 lb/A. Broadleaf weed control was satisfactory at 4 to 8 lb/A in those plots in which pigweed and smartweed were the dominant broadleaf species.

Mode of Action

Diphenamid has no activity against non-germinating seeds. It is highly active against susceptible germinating seedlings. However, established plants of susceptible species can be severely damaged or killed by post-emergent application at higher levels. In a number of turf experiments it was found that rates of 20 lb/A of diphenamid granules completely killed turf grasses such as bluegrass, bentgrass, and Bermuda grass.

Diphenamid is absorbed through the roots of susceptible plants and shows little or no contact foliar activity. In instances where susceptible plants have not been completely killed by the compound, the root system is usually severely stunted.

Three points remaining to be clarified are: 1) to what extent does translocation of diphenamid occur, 2) how is diphenamid metabolized, and 3) what is the basis for selective action (i.e., do tolerant species fail to absorb diphenamid, or is the chemical absorbed but without effect)? Chemical and tracer studies are now under way which should elucidate these points.

Summary

1. N,N-dimethyl-α,α-diphenylacetamide, formerly L-34314, now tentatively named diphenamid, was found to possess desirable herbicidal activity in the field against seedling grasses and many broadleaf weeds at 4 to 8 lbs/A.

2. Tomatoes, alfalfa, soybeans, cotton, and a number of vegetable crops have not been damaged by diphenamid at application rates which have given good weed control.

COMBINATIONS OF CDEC WITH CDAA AND OTHER COMPOUNDS FOR WEEDING VEGETABLES

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Growers frequently use several insecticides or fungicides in combination in order to control the range of pests that may attack a given vegetable. However, the use of herbicides in combination is negligible, except in a few isolated cases such as CIPC plus CDAA for weed control in onions on muck soils. The great majority of other herbicide treatments involve one chemical applied once to a given crop.

Since vegetables almost always have two or more weed species prevalent in a given field, and since the areas of production are scattered over many soils and climates, a tremendous number of weed species are potential pests for any given vegetable planting. It is highly unrealistic to expect one herbicide to be effective under all these environmental conditions and against all possible weed species.

The purpose of the studies reported here was to make a small start toward the much needed and extremely complicated problem of evaluating herbicide combinations.

Experimental.

Since these tests were considered to be only a partial attack on a large problem, the number of chemicals was arbitrarily limited. Two general types of tests were included 1) logarithmic combinations of two chemicals and 2) specific rates of chemicals on a given series of plots. All tests were located on a Dunkirk sandy loam.

Logarithmic Test

The logarithmic type applications were made with a conventional logarithmic sprayer mounted on a Jeep.1/ The applications of the two chemicals involved were made simultaneously by having one chemical in the concentrate tank and the other in the diluent tank. In another plot the position of the two chemicals in the sprayer was reversed. Each plot was 50 feet long. The sprayer was operated so that the half dosage distance was 20 feet.

On July 29 the experimental area was fitted to a very fine seed bed and divided into plots 6 x 50. In the central portion of the plot six rows of vegetables were seeded immediately lengthwise of each plot. Rows were spaced six inches apart. This left adequate area for the Jeep to travel over the plots without damage to the seeded area. Each treatment was replicated twice.

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1/ Loaned by Dr. S. N. Fertig of the Cornell University Agronomy Department.

Due to thunderstorms and difficulty with the apparatus, the treatments were applied at different times. The chemicals, rates, and times of application are listed in Table 1.

Table 1. Crop response to logarithmic combinations of several herbicides.

Test	Chemical and rate	Date Applied*	Beets	Spin.	Tom.	Cab.	Broc.	Lettuce
			Crop Response1/					
A	CDEC 6 + CIPC 2	July 29	4.5	4.5	3.5	4.5	7.0	7.5
	" 3 + " 3		2.0	2.5	2.0	4.0	4.0	7.0
	" 2 + " 3.25		2.0	2.0	1.0	2.5	2.5	6.5
B	CIPC 2 + CDEC 6	Aug. 1	5.0	4.0	1.5	3.0	3.5	9.0
	" 1 + " 9		3.5	2.0	1.5	3.5	4.5	8.0
	" .75 + " 10		1.5	2.0	2.0	2.5	4.5	6.5
C	CDAA 3 + CIPC 2	July 29	5.0	4.5	3.0	4.5	5.5	5.5
	" 1.5 + CIPC 3		4.0	3.5	1.0	2.5	3.0	6.0
	" 1 + CIPC 3.25		3.0	3.0	1.0	1.5	1.5	4.0
D	CIPC 2 + CDAA 3	Aug. 1	2.5	4.0	1.0	1.5	2.5	5.0
	" 1 + " 4.5		4.5	3.0	2.5	3.0	5.5	6.5
	" .75 + CDAA 5		3.5	3.0	1.0	3.0	4.5	5.0
E	CDEC 6 + CDAA 3	Aug. 1	5.0	3.0	7.0	3.5	4.5	5.5
	" 3 + " 4.5		5.5	5.0	7.5	4.0	6.0	8.0
	" 2 + " 5		3.5	4.0	5.5	3.5	5.5	5.5
F	CDAA 3 + CDEC 6	Aug. 1	7.0	5.5	6.5	6.5	8.0	7.5
	" 1.5 + CDEC 9		6.0	6.0	6.5	6.0	6.5	6.5
	" 1 + CDEC 10		4.0	4.5	7.0	4.5	6.5	7.5

Test	Chemical and rate	Date Applied*	Carrots	Tom.	Cab.	Broc.	Lettuce
G	CDEC 6 + Solan 4	Aug. 5	7.5	5.5	1.0	1.0	1.0
	" 3 + " 6		6.5	1.0	1.0	1.0	1.0
	" 2 + " 7		7.0	3.0	1.0	1.0	1.0
H	Solan 4 + CDEC 6	Aug. 5	8.0	3.5	1.0	1.0	1.0
	" 2 + " 9		7.0	4.0	1.0	1.0	1.0
	" 1.5 + CDEC 10		6.0	2.0	1.0	1.0	1.0
I	Dacthal 4 + Solan 4	Aug. 5	8.0	1.5	1.0	1.0	1.0
	" 2 + " 6		7.5	2.0	1.0	1.0	1.0
	" 1.5 + Solan 7		6.5	1.5	1.0	1.0	1.0
J	Solan 4 + Dacthal 8	Aug. 5	9.0	3.5	1.0	1.0	1.0
	" 2 + " 12		9.0	1.0	1.0	1.0	1.0
	" 1.5 + " 13		9.0	1.0	1.0	1.0	1.0

1/ 9 = perfect; 7 = commercial; 3 = severe damage; 1 = kill.
* Fitted and seeded July 29.

Results

The delay in application time undoubtedly had an important influence in the results because the weed and crop seeds were actively germinating almost immediately. At the time of the August 5 application many seedlings were at or near the soil surface. Chemicals which have contact action were favored when applied at this date. Conversely, chemicals which act as germination inhibitors were undoubtedly penalized.

A few of the data obtained on crop response are presented in Table 1. From them several important facts can be noted. When Solan is applied to sprouting crops it can be very toxic. Carrots show good tolerance to Solan in mixtures. It is also apparent that CIPC in the combination was likely to be somewhat toxic, except possibly to lettuce. This trend has been noted by the authors in seeded crucifer experiments, not reported here. The most favorable combination seemed to be CDEC and CDAA.

Weed control was generally good in these tests. The most spectaclar results were obtained with the Solan combinations. Here both contact and preventative type chemicals were involved and the plots stayed weed free the remainder of the season.

CDAA plus CDEC Test

Since response of crops and weed control were rather good with CDEC plus CDAA combinations, it was decided to give them detailed testing by means of specific dosages on a series of plots.

An area was fitted, seeded, and treated August 24. Plots were 6' x 15' and each contained two rows of tomatoes, cabbage, broccoli, spinach, lettuce, carrots, and beets. Good moisture prevailed because of irrigation and rain. Crop growth was generally good. Weed populations were heavy and consisted of crabgrass, barnyard grass, red root pigweed, and purslane. Information on chemicals, rates, crop response and weed control are presented in Table 2. However, flea beetles damaged the crucifer seedlings so severely that data from these two crops are omitted from the table.

Individual crops responded somewhat differently. Tomatoes and spinach were quite tolerant of practically every dosage and combination of CDAA and CDEC. Carrots and beets were severly stunted by the highest combinations; somewhat less stunted by high single treatments or moderate combinations. Neither crop was injured by the lower combinations or single treatments. Lettuce was the most sensitive of any crop to high or intermediate rates of CDAA. Injury was much greater when CDEC was applied in combination with CDAA. Only at the lowest rates did CDAA alone or in combination with CDEC fail to injure lettuce.

One of the most striking features of this test was the enhanced kill of weeds that was obtained by combinations of CDEC and CDAA as compared to either chemical applied singly. It can be seen in Table 2 that even as much as eight pounds of CDAA gave poor control of broadleaves and a similar rate

Table 2. Crop and weed response to combinations of CDAA and CDEC applied at planting. Observations taken five weeks later.

Treatment			Crop Response[1]					Weed Response[2]	
	CDEC	CDAA	Lettuce	Carrot	Beet	Spinach	Tomatoes	BL	Grass
1.	8	4	3.5	5.5	4.5	7.0	7.0	9.0	9.0
2.	4	8	2.5	5.5	4.0	7.0	7.0	9.0	9.0
3.	8	0	8.0	6.5	6.5	7.5	8.5	8.5	6.5
4.	0	8	3.0	7.0	7.5	8.5	8.0	5.5	9.0
5.	6	3	4.5	7.0	6.5	8.0	8.0	9.0	8.5
6.	3	6	3.0	6.5	5.0	7.5	-	7.5	8.5
7.	6	6	3.0	6.0	5.5	7.0	-	8.5	8.5
8.	6	0	8.5	7.0	8.0	7.5	7.5	7.0	6.5
9.	0	6	-	-	7.5	7.0	7.5	5.5	7.0
10.	3	3	7.0	6.0	7.5	8.0	8.0	7.0	7.0
11.	3	0	9.0	7.5	8.0	8.0	8.0	5.0	4.0
12.	0	3	8.0	7.5	8.5	8.5	8.0	3.0	4.0
13.	4	2	7.0	7.5	8.5	8.0	8.0	7.5	6.0
14.	2	4	7.5	7.5	8.5	8.5	8.0	6.0	5.5
15.	4	4	5.5	7.5	7.5	7.0	8.0	7.0	7.5
16.	4	0	8.5	8.0	8.5	7.5	8.5	6.5	4.5
17.	0	4	7.5	8.0	8.0	8.0	8.5	5.5	7.0
18.	2	2	8.0	7.5	7.5	7.5	9.0	6.0	6.0
19.	2	0	8.0	8.0	8.0	7.5	9.0	4.0	4.0
20.	0	2	8.0	8.0	7.5	7.0	9.0	3.0	5.5
21.	2	1	8.5	8.5	8.5	9.0	9.0	5.0	6.0
22.	1	2	8.0	8.0	8.5	8.5	9.0	4.0	7.0
23.	1	0	9.0	8.0	9.0	8.5	8.5	3.5	4.0
24.	0	1	8.5	8.0	8.0	8.0	8.0	3.5	6.0
25.	Check		8.0	7.5	8.0	8.5	7.0	3.5	3.0

1/ 9 = perfect crop; 7 = acceptable; 5 = stunting; 3 = severe damage; 1 = kill.
2/ 9 = perfect control; 7 = acceptable; 5 = additional weeding needed; 1 = complete ground cover.

of CDEC was weak on grasses. However, combinations totaling only 4 to 6 pounds of chemical, especially at 1-1 ratios, gave good control of both broadleaves and grasses.

Perhaps the most important aspect of these results was that weed control improvement was obtained by means of combinations without any apparent increase in crop sensitivity except for lettuce. With this crop CDAA proved too toxic whether applied alone or in combination. Of course, at very low rates the toxicity disappeared, but weed control is questionable at these levels.

Summary

Logarithmic, tank-mixed combination application of CDEC and CDAA, CDEC and CIPC, CDAA and CIPC, CDEC and Solan, and Dacthal and Solan showed that CDEC and CDAA had promise for good weed control without damage to a wide range of seeded vegetable crops. CIPC in combination with CDEC proved relatively toxic. Solan and Dacthal gave excellent results on carrots.

In an extensive follow-up test of CDEC and CDAA combinations, it was shown that beets, spinach, tomatoes, carrots and, perhaps, crucifers offer opportunity for safe usage. Lettuce proved too susceptible to CDAA.

Weed control as measured by heavy populations of red root pigweed, purslane, crabgrass and barnyard grass, was markedly improved by CDEC-CDAA combinations even at relatively low dosages.

Considerable more work needs to be done in the area of herbicide combinations for vegetables under a wide range of soils, environment, and weed specie populations. However, it appears that CDEC and CDAA offer a promising start.

Post-Transplanting and Lay-By Weed Control In Processing Tomatoes

Charles H. Moran*

Favorable weather conditions in 1960 and the use of new improved varieties resulted in the highest average tomato yields ever obtained in New Jersey. A record mean yield of 15.5 tons per acre was estimated by the Crop Reporting Service at the close of the season on October 1. The same weather conditions also afforded one of the better tests for herbicide effectiveness experienced in recent years. Annual grasses, particularly crabgrass, were the major weed competitors in commercial tomato fields. The following report presents the results of two series of experiments designed to control these competitors chemically.

METHODS AND MATERIALS

Similar field experiments were established on a Downer loamy fine sand and a Collington fine sandy loam near Moorestown, New Jersey.

Southern grown tomato plants of the variety 146 were planted in the Downer and Collington soils May 11 and May 14, respectively. Treatments were replicated four times in randomized blocks. Each plot was 4 rows wide x 20' long. Plants were spaced 2 feet apart in rows which were 5 feet apart. Harvest records were obtained from the center 2 rows.

At each location there were two experiments. In the first, designated as post-transplanting, the herbicides were broadcast within three weeks of transplanting and no further treatments made. Check plots were, however, kept weed free by hoeing until the time of lay-by. In the second experiment, designated as lay-by, the plots were tractor cultivated and hand hoed as required until spread of the vines stopped passage of the tractor.

The dates, rates of application and materials used in the four experiments are shown in Table 1. Sprays were applied broadcast with a single nozzle hand sprayer using the equivalent of 50 gallons of water per acre. Granular materials were spread by means of a hand shaker.

Eptam was mixed with the surface soil by means of tractor cultivation.

The principal weeds on the Downer sand were crabgrass (Digitaria sanguinalis (L) Scop), lambs-quarters (Chenopodium album L.), and pigweed (Amaranthus retroflexus L.). Foxtail (Setaria viridis (L) Beauv), bindweed

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Table 1

Rates and Dates of Herbicide Treatments on Two Soil Types - 1960

Herbicide	Lbs* a.i./A	Carrier	Post-Transplanting Application Downer lfs	Post-Transplanting Application Collington fsl	Lay-By Application Downer lfs	Lay-By Application Collington fsl
Amiben 10 G	4	Granule	June 1	June 3	July 12	July 19
Dacthal 50 WP	8**	Spray	June 1	June 3	July 12	July 19
Eptam 5 G	4	Granule	June 1	June 3	July 12	July 19
Neburon 4 G	4	Granule	June 1	June 3	July 12	July 19
Solan N4512	4	Spray	June 15	June 17	July 12	July 19
Zytron 25 G	15	Granule	June 1	--	July 12	--

* a.i./A - active ingredients per acre.

** 12 lbs. of Dacthal were used at lay-by.

(*Convolvulus arvensis* L.) and ragweed (*Ambrosia artemisiifolia* L.) appeared in occasional patches.

On the Collington loam soil, ragweed was the primary broadleaf weed. Crabgrass and switchgrass (*Panicum* spp.) were the principal grasses.

Weed control was rated independently by two men on September 20. Scoring was delayed in order to obtain a measure of the treatments ability to furnish full season weed control.

RESULTS

Post-Transplanting. The mean control ratings shown in Table 2 indicate that the herbicides broadcast in early June were not effective in suppressing weed growth for the subsequent 16-week period.

Table 2

Effect of Post-Transplanting Herbicide Treatments on Late Season Weed Control in Tomato Fields on Two Soil Types

Treatment	Downer Loamy Fine Sand Grass	Downer Loamy Fine Sand Broadleaf	Collington Fine Sandy Loam Grass	Collington Fine Sandy Loam Broadleaf
	Mean Control Rating*			
Check	1.5	3.4	1.5	4.4
Amiben	3.3	2.9	2.9	2.8
Dacthal	2.6	1.5	4.4	1.0
Eptam	3.7	3.0	1.7	1.0
Neburon	1.3	2.7	1.3	1.3
Solan	1.0	3.9	1.0	1.4
Zytron	1.0	3.5	-	-
LSD .05	1.3	1.0	1.4	1.0
.01	1.7	1.4	1.9	1.5

* 1 - no control, 5 - excellent control
Rating of 4.0 or higher would be commercially acceptable for the rating period.

The effects of plant competition were reflected in the yields, and fruit size (Table 3). For example, Neburon treated plots yielded 9.57 and 7.11 tons of tomatoes less than the check plots on the Downer and Collington soils, respectively. Fruit from the Neburon, Solan and Zytron treated plots tended to be smaller than those from the check. Reduction in size is indicated by the increase in number of fruit required per 35-pound hamper. The differences may be attributed chiefly to the lack of weed control in the period between treatment and lay-by when the check plots were kept weed free.

Eptam treatments on the Downer loamy sand resulted in considerable leaf burn and epinasty. The plants recovered quickly and the treated plots

Table 3

Effect of Post-Transplanting Herbicide Treatments on the Yield and Quality of Processing Tomatoes - 1960

	Downer Loamy Fine Sand				Collington Sandy Loam			
Herbicide	Yield Tons/Acre	Fruit Per 35 lbs.	Color Index	Titratable Acidity	Yield Tons/Acre	Fruit Per 35 lbs.	Color Index	Titratable Acidity
Check	18.56	115	90.4	6.5	24.93	108	91.1	6.3
Amiben	19.67	121	90.3	6.3	25.04	112	87.7	6.8
Eptam	19.06	97	92.1	6.3	20.39	122	89.0	6.8
Dacthal	15.22	117	91.2	6.7	17.64	145	87.5	7.4
Neburon	8.99	148	86.3	6.8	17.82	131	87.0	7.1
Solan	13.84	124	88.4	6.2	19.78	133	89.4	7.3
Zytron	10.38	132	88.5	6.7	-	-	-	-
LSD .05	5.39	14	3.07	N.S.	3.01	13	N.S.	N.S.
.01	7.39	19	N.S.	N.S.	4.17	19	N.S.	N.S.

yielded as much as the check plots; 19.06 and 18.56 tons per acre, respectively. The same treatments on the Collington loam soil did not injure the plants.

Lay-By. Eptam was the only herbicide in the lay-by experiments that received a score of 4.0 or better on both soils for the control of grasses and broadleaf weeds, Table 4. The rating of 4.0 was considered for that time of season to be the threshold level of commercial acceptance.

Amiben afforded good weed growth suppression on the Collington loam soil but was not effective on the Downer loamy sand. The loss in efficiency on the sandy soil may have been the result of a carrier x moisture interaction. There was no rain for 10 days after herbicide application. Weeds, primarily crabgrass, became established during this period.

Dacthal applied at rate of 8 pounds per acre June 3 in the Collington post-transplanting plot test resulted in better weed control than 12 pounds applied at lay-by, July 19. Reasons for this behavior were not readily apparent.

Neburon, Solan and Zytron at the rates employed were not effective lay-by herbicides for processing tomato fields in which the chief natural plant competitors were grasses. All of the materials were rated equal in control of broadleaf weeds.

Neither yields, color nor acidity were affected by any of the lay-by herbicide treatments, Table 5.

Table 4

Effect of Lay-By Herbicide Treatment on Late Season Weed Control in Tomato Fields on Two Soil Types

Treatment	Downer Loamy Fine Sand Grass	Downer Loamy Fine Sand Broadleaf	Collington Fine Sandy Loam Grass	Collington Fine Sandy Loam Broadleaf
	Mean Control Rating*			
Check	1.0	3.7	1.0	3.9
Amiben	3.1	3.9	4.1	4.3
Dacthal	4.5	4.1	2.9	3.2
Eptam	4.8	4.0	4.4	4.2
Neburon	1.0	3.9	1.3	4.2
Solan	1.0	4.5	1.3	4.2
Zytrol	2.2	3.7	-	-
LSD .05	0.8	N.S.	1.0	N.S.
.01	1.1	-	1.5	-

* 1 - no control, 5 - excellent control.
Rating of 4.0 or higher would be commercially acceptable for the rating period.

Table 5

Effect of Lay-By Herbicide Treatments on the Yield and Quality of Processing Tomatoes - 1960

	Downer Loamy Fine Sand				Collington Sandy Loam			
Herbicide	Yield Tons/Acre	Fruit Per 35 lbs.	Color Index	Titratable Acidity	Yield Tons/Acre	Fruit Per 35 lbs.	Color Index	Titratable Acidity
Check	17.42	122	92.6	5.9	21.92	105	92.4	7.4
Amiben	24.56	109	94.0	6.2	22.27	105	93.6	7.2
Eptam	20.35	109	94.9	6.7	23.35	105	92.9	7.4
Dacthal	18.89	108	92.2	6.3	23.19	108	90.8	7.1
Neburon	20.06	115	91.8	6.6	24.33	101	93.3	7.0
Solan	21.70	106	93.7	6.0	20.76	109	92.0	7.4
Zytron	19.29	109	95.5	6.1	-	-	-	-
LSD .05	N.S.	12	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
.01	N.S.	16	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

SUMMARY

Post-transplanting and lay-by tests of Amiben, Dacthal, Eptam, Neburon and Solan were conducted with processing tomatoes on two soil types. The soils, located near Moorestown, New Jersey, were Downer loamy fine sand and Collington fine sandy loam. The compound Zytron was included only in the experiments on the Downer sand.

More of the herbicides applied broadcast approximately 3 weeks after transplanting were effective in suppressing weed growth for the subsequent 16-week period. Highly significant reductions in yield and fruit size were resulted from Dacthal, Neburon and Solan treatments on the Collington loam, and from Neburon, Solan and Zytron on the Downer sand.

Eptam treatments on young tomato plants on the sand resulted in leaf burn and epinasty. Similar treatments at lay-by injured the plants only slightly. No injury was observed in either experiment on the loam soil.

Eptam was the only material tested at lay-by that controlled both grasses and broadleaf weeds on the two soil types.

Amiben was as effective as Eptam on the Collington loam. On the Downer sand, Amiben did not suppress growth of grasses as well as Eptam. Loss of efficiency on the sand was attributed to low soil moisture.

Chemical Weed Control in Beets

Charles J. Noll[1]

Chemical weeding of beets has been practiced for a good many years. No single treatment has been universily successful. Commercially beets are weeded with salt, Vegadex, Endothal, TCA or a combination of chemicals. All these chemicals have their limitations. The following report is a summary of work completed during 1960.

Procedure

The variety Seneca Detroit was seeded May 2, 1960. The pre-planting treatments were applied the day of planting and incorporated in the soil with a roto-tiller set shallow. The pre-emergence treatments were applied 8 days after seeding, the emergence treatments 14 days after seeding and the salt treatment 35 days after seeding when beets had 4-5 true leaves. Individual plots were 28 feet long and 2 feet wide. Treatments were randomized in each of 8 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. The growing season was cooler than usual and rainfall less than normal. An estimate of weed control was made on June 30 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Beet harvest was completed September 27.

Results

The results are presented in Table 1. All chemicals significantly increased weed control as compared to the untreated check except TD 62 applied pre-emergence or TD 47 applied post-emergence on the combination of the two. The best weed control was with the pre-planting treatments of EPTC and R-2061, the combination pre-emergence treatment of Endothal and TCA and the pre-emergence treatment of Zytron.

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Two chemicals significantly reduced the stand of beets. These were Zytron and salt. Twelve treatments significantly increased the yield of marketable beets and compared to the untreated check. These treatments include all pre-planting treatments with EPTC or R-2061, all pre-emergence treatments with TCA, either alone or in combination with Endothal, TD 62, or TD 47, the treatment of Endothal and TD 47 and Vegadex treatments. The best yields were obtained with plots treated with TCA in combination with Endothal or TD 62 in a pre-emergence application or with R-2061 in a pre-planting application.

Conclusion

In this years experiment the best yields were in plots receiving the combination treatment of Endothal and TCA applied just prior the emergence of the beets. The chemical R-2061 applied prior to planting and incorporated in the soil looks promising for the weeding of this crop.

Table I. Weed control, plant stand, and weight of marketable beets under chemical herbicide treatments.

Chemical First Application	Chemical 2nd Appl.	Active Rate Per Acre lbs. 1st Appl.	Active Rate Per Acre lbs. 2nd Appl.	Days from Seeding 1st Appl.	Days from Seeding 2nd Appl.	AVERAGE PER PLOT Weed* Control (1-10)	AVERAGE PER PLOT Stand of Plants	AVERAGE PER PLOT Wt. of Mkt. Roots lbs.
Nothing		--	--	--	--	8.5	236	5.6
°EPTC		4	--	0	--	1.8	215	9.3
"		6	--	0	--	2.0	264	11.6
°R-2061		4	--	0	--	2.6	292	14.1
"		6	--	0	--	3.0	272	12.3
Endothal		6	--	8	--	5.8	256	8.2
TCA		10	--	8	--	4.1	244	10.7
Endothal & TCA		6+10	--	8	--	3.0	262	13.4
TD 62		6	--	8	--	7.3	240	6.7
TD 62 & TCA		6+10	--	8	--	3.6	285	13.1
Endothal	TD 47	6	1	8	14	4.4	289	10.8
Endothal & TCA	TD 47	6+10	1	8	14	2.0	262	15.0
TD 62	TD 47	6	1	8	14	7.4	246	6.8
TD 62 & TCA	TD 47	6+10	1	8	14	3.6	277	12.4
TD 47		2	--	14	14	7.5	253	6.7
CDEC(Vegadex)		6	--	8	--	5.1	246	9.7
" "		9	--	8	--	4.0	238	10.9
Zytron		10	--	8	--	2.8	21	1.3
"		15	--	8	--	2.4	12	.6
Salt		400	--	35	--	4.8	123	4.6
Least Significant Difference 5%						1.3	51	3.5
" " " 1%						1.7	68	4.6

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

°Soil incorporation prior to planting.

PRE-EMERGENCE WEED CONTROL TESTS IN TABLE BEETS

M. W. Meadows(1), S. A. Anderson(2), L. E. Curtis(1), and R. P. Hargan(1)

Problem: Weeds pose a major problem in the table beet acreage of New York State. A number of herbicides have been tested by research workers and used by growers -- few have been very effective in reducing hand weeding costs primarily due to inability of the chemicals to control lambsquarter without seriously injuring the beets.

Materials - Expt. I was conducted on an Ontario Silt Loam soil at Gorham, N. Y.

Detroit Red beets were planted June 30, 1960.

Eptam and Stauffer 2061 were applied and disced into the soil on June 23. Pre-emergence materials were applied on the day of planting, June 30. Post-emergence herbicides were applied July 18.

Sprays were applied with a knapsack type sprayer at the rate of 60 gallons per acre. Fertilizer borate was dusted on with a hand duster. All herbicides were applied overall except Solubor and Fertilizer borate. These materials were applied in an 8 inch band centered over the beet row.

Expt. II was conducted on a Sandy Loam soil at Ithaca, N. Y.
Eptam and Stauffer 2061 were applied 7/8/60 on plots 6' x 30' that were randomly replicated 4 times. The materials were applied in 60 gallons of water per acre and immediately disced into the soil.

Successive plantings of beets were made 7/8/60; 7/15/60; and 7/26/60.

A light spring tooth harrow was run over the soil in order to make the 3rd planting.

Results: Expt. I
Table 1 gives the results of weed control and beet injury.

(1) G.L.F., Ithaca, N. Y.
(2) Comstock Foods, Inc., Newark, N. Y.

Table 1 - Table Beets
Pre-plant; Pre-emergence and Post-emergence Weed Control on Table Beets

Planted June 30, 1960; Pre-plant treatments June 23; Pre-emergence June 30; Post-emergence July 18, 1960. Data 7/18/60 and 8/1/60.

Chemical	Lbs. Active Acre Rate	Timing	Method of Application	*Beets	*Weeds
Vegadex	4	Pre	Spray	1.0	3.5
"	6	"	"	2.3	4.2
**Fertilizer Borate	13.8	"	8" band	0.7	3.2
"	27.8	"	dusted on	1.2	3.2
"	55.6	"	"	2.2	4.0
**Solubor	13.8	"	8" band	0	1.5
"	27.8	"	spray	0.8	2.8
"	55.6	"	"	2.3	4.2
"	13.8	Post	"	0.7	1.0
"	55.6	"	"	0.3	0.7
Diuron	0.4	Pre	"	2.7	4.3
Niagara 2995	2	"	"	2.8	4.0
"	4	"	"	4.0	5.0
TD47	2	"	"	0.3	0.3
"	4	"	"	0	0
TD62	2	"	"	0.7	1.0
"	4	"	"	2.7	1.3
Eptam	4	Pre-plant	"	1.2	5.0
"	6	"	"	2.0	5.0
Stauffer 2061	4	"	"	1.3***	3.8
"	6	"	"	0.7	5.0
Check	-			0	0

* Visual rating system
0 = No weed control - no crop injury.
5 = Complete weed control - complete crop destruction.
Weeds - Primarily lambsquarter and redroot, a few annual grasses and ragweed were present.

** The rates given for Fertilizer borate and Solubor are based on elemental Boron and not manufactured product.

Rates given refer to the rate per acre in an 8" band. The total rate of Boron delivered per planted acre would be 1/3 of that reported in table 1.

*** A majority of injury in one treatment was suspected to be due to competition of a hedgerow that was near one plot of this treatment

Discussion: Expt. I
Treatments worthy of note from the standpoint of weed control and lack of beet injury are as follows: 4 lbs. Vegadex; 13.8 and 27.8 lbs. Boron in Fertilizer Borate; 4 lbs. Eptam pre-plant and 4 and 6 lbs. Stauffer 2061 pre-plant.

Stauffer 2061 was outstanding.

There is considerable advantage to a Borax treatment since fertilizers usually contain enough fertilizer grade Borate to supply 40 lbs. borax per acre as was supplied with the 13.8 lb. Boron rate of Solubor and Fertilizer borate. The 27.8 and55.6 Boron rates could leave toxic residues in the soil that would affect other crops grown in rotation with beets.

As the season progressed Beets overcame the earlier stunting effects caused by Boron.

Expt. II
The results of Expt. II are given in table 2.

Table 2 - Table Beets
Tolerance of Beets and Weed Control Obtained with Eptam and Stauffer 2061 Applied and Incorporated into the Soil 7/8/60 -- Beets Planted 7/8/60; 7/15/60; and 7/26/60. Observations 8/19/60.

Time elapse between application of herbicide and planting of beets	*Material and Rate			
	Eptam		2061	
	4 lbs.	6 lbs.	4 lbs.	6 lbs.
Immediately	3.37	4.0	0.25	0.62
7 days	3.31	4.37	0.12	1.5
18 days	2.75	3.75	0.25	0.5
Weed Control	4.6	4.9	3.2	4.6

*Rating system same as in table 1.

Discussion: Expt. II
These data would indicate that table beets have a higher degree of tolerance to Stauffer 2061 than to Eptam. Beets planted the day of application showed only slight stunting from 2061 as compared to almost complete crop destruction by Eptam.

Eptam at equivalent rates gave better weed control than Stauffer 2061.

Chemical Weed Control in Onions Grown on Mineral Soils

Charles J. Noll [1]

In the 1959 onion weeding experiment only one chemical, CIPC, out of 7 chemicals in the test offered promise for the weeding of this crop. In last years experiment there was found to be an increase in onion yield and an increase in weed control as the rate of CIPC application increased from 4 to 6 to 8 lbs. per acre applied the day after seeding. The possibility that time of pre-emergence application might be important as well as rate of application was taken into consideration in planning work in 1960.

Procedure

The variety Sweet Spanish was seeded May 2, 1960. The pre-emergence treatments were applied from 2 to 10 days after seeding. The emergence treatment with KOCN was made 19 days after seeding and the post-emergence treatments with Atratone 30 days after seeding. The soil at planting time was dry and no rain fell until the 6th day after seeding. Sufficient rain was received from the 6th day after seeding through the next few days to germinate the onions and weeds. Individual plots were 28 feet long and 2 feet wide. Treatments were randomized in each of 8 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. The growing season was cooler than average and rainfall below normal. An estimate of weed control was made June 30 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Onions were harvested September 28.

Results

The results are presented in Table 1. All chemicals gave highly significant increase in weed control as compared to the untreated check. All chemicals, except Dacthal had increasing weed control as the rates of application increased. Dacthal had equal weed control at 6, 9, and 12 lbs. per acre. Weed control was generally from fair to poor. The time of application of CIPC had little effect on the weed control rating, although in general the later applications resulted in poorer weed control.

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The stand of plants was best with the Dacthal treatments. Where CIPC was applied the best stand of plants was on plots receiving 4 lbs. of CIPC per acre 10 days after seeding. Earlier application and heavier rates of application greatly reduced the stand. Atratone greatly reduced the stand of onion plants as compared to the better treatments at rates of both 1 and 2 lbs. per acre. There was no difference in stand of onion plants where KOCN was applied at 12, 18 or 24 lbs. per acre.

Yields were generally poor. The Dacthal treatment, applied 2 days after seeding, at the rate of 12 lbs. per acre gave a highly significant increase in yield as compared to all other treatments. Other Dacthal treatments compared favorable with the best of the CIPC treatments. The best CIPC treatment in regards to yield was where CIPC was a pplied at 4 lbs. per acre 10 days after seeding, other times of application and rates were generally unsatisfactory. KOCN and Atratone gave unsatisfactory yield.

Conclusion

Dacthal offers promise in the weeding of onions. In this experiment the highest rate of treatment 12 lbs. per acre gave the best yield although weed control was no better than where 6 pounds was applied. CIPC gave best yields when the application was delayed. It is possible that in this experiment yields would even be greater if the CIPC treatment had been applied even later than 10 days after seeding.

Table I. Weed control, plant stand and weight of Onions under chemical herbicide treatments.

Chemical	Active rate Per Acre lbs.	When Applied Days from Seeding	AVERAGE PER PLOT *Weed Control (1-10)	Stand of Plants	Wt. Onion lbs.
Nothing	--	--	9.3	29	.5
CIPC	4	3	4.3	19	1.0
"	8	3	2.9	9	.6
"	12	3	2.4	3	.2
CIPC	4	5	3.9	26	1.2
"	8	5	3.0	7	.6
"	12	5	2.4	3	.2
CIPC	4	8	4.0	78	2.9
"	8	8	3.0	38	2.2
"	12	8	3.1	24	1.5
CIPC	4	10	5.1	94	4.3
"	8	10	3.6	56	2.8
"	12	10	3.3	51	2.5
KOCN	12	19	6.9	74	1.8
"	18	19	5.9	80	2.1
"	24	19	4.9	71	2.5
Dacthal 893	6	2	3.0	98	4.1
"	9	2	2.9	121	5.6
"	12	2	3.4	121	7.7
Atratone	1	30	2.5	23	1.2
(G32293)	2	30	1.4	2	.2
Least Significant Difference		(P=.05)	1.2	29	1.8
" "		" (P=.01)	1.6	38	2.4

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

Weed Control with Randox[1] T in Corn and Onions

R. E. Althaus[2], Robert W. Langlois[3] and L. S. Gleason[2]

Randox T is a combination of CDAA (or chloro-N,N-diallyl acetamide) and trichlorobenzyl chloride. This product is an outgrowth of Randox[1] which is used for weed control in corn and soybeans. Early research and development work and later field experience demonstrated that Randox (CDAA) was particularly effective against grasses when applied as a pre-emergence treatment. Broadleaf weed control is moderately good except for smart-weed and lambsquarters. In areas of the Midwest where foxtail (Setaria sp.) is the principal weed species, Randox is still the preferred herbicide, but in areas where broadleaves are troublesome, practical weed control with Randox is marginal.

The Monsanto Agricultural Research Laboratories discovered that it was possible to combine trichlorobenzyl chloride (TCBC) and Randox (CDAA) and achieve broad spectrum weed control which includes such weeds as foxtails, crabgrass, annual blue grass, sandbur, ragweed, annual morning glory, smartweed, butterprint, pigweed, purslane, Russian thistle, lambsquarters, mustard and groundsel (1,2).

Randox T was introduced commercially in 1960 for use on field corn both as an emulsifiable and as a granular formulation. Both formulations are equally effective in weed kill and crop tolerance and can be used in either form depending upon the grower's preference.

A survey was conducted by the Monsanto field sales force to evaluate the field performance under grower use. The survey was conducted in a manner such that the data were recorded as the opinion of the farmers interviewed. This comprised interviews with 162 growers located in the 11 Midwestern states. The results are presented in Table I.

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[1]Registered trademark of the Monsanto Chemical Company

[2]Monsanto Chemical Company, St. Louis, Missouri

[3]Assoc. County Agricultural Agent. Orange County, New York

Table I

Results of Randox T Performance
Survey in Eleven States 1960

	RATING			
	Excellent	Good	Fair	Poor
Grass Control	68	64	18	12
Broadleaf Weed Control	87	51	16	8

The excellent rating is considered as near perfect control of all weeds, the good classification as a level of weed control in which scattered weeds were present in the field on band, the fair category as a level of weed control where the stand of weeds was reduced but where cultivation would be required to achieve complete control and the poor rating as when unacceptable weed control was obtained. It should be emphasized that some of the poor classification resulted from poorly prepared seed beds or application on light or sandy soils, for which Randox T is not recommended. The results of this survey show a good record for commercial use in spite of the fact that environmental factors were not considered ideal for Randox T. Records from these same survey forms show that the average time of the first rain for all applications in all states was 3½ days and was approximately 1 inch in amount. The range in rainfall was 0.1 to 5 inches for the first rain. These conditions are considered as above normal rainfall for the corn belt.

Randox T has shown some promise for peas, carrots and onions at rates ranging from 4 to 8 qts. per acre. Excellent weed control was obtained in Canada (3) with Randox T on celery. Directed sprays caused slight initial tip burn of the lower leaves of celery but the plants recovered rapidly and gave the highest yields of any of the plots. Preliminary studies in Minnesota on onions demonstrated promise both from the standpoint of weed control and crop tolerance. To evaluate this use more intensively, several experiments were initiated in 1960 in Orange County, New York.

Five grower sites were selected on the basis of varying muck soil types, different seeding dates, various insecticide-fungicide treatments and different onion varieties. Replicated plots in a randomized design were set up on rows adjacent to ditch banks where weed density is high.

Spray applications were made with a hand sprayer fitted with a boom at a volume rate of 45 gallons per acre. Granular applications were made with a small hand duster which provided good uniform distribution.

Standcounts were made approximately 4 weeks later and results are presented in Table II.

Table II

Onion Stands Following
Pre-emergence Applications of Randox T

Treatments			Percent stand* 20' row
	Formulation rate		
Randox T	Randox	CDAA equivalent per acre	
6 qts.		4.2	94
9 "		6.3	91
12 "		8.4	86
42 lbs.		4.2	89
63 "		6.3	75
84 "		8.4	72
	30 lbs.	6.0	86
	6 qts.	6.0	88

* average 10 replicates
5 test areas

These results combine the average of treatments made from 1 to 14 days after application. These averages are depressed somewhat by the influence of the treatment made 1 day after seeding. This can be expected since Randox alone causes more than tolerable reductions of stand if applications are made immediately following seeding particularly if heavy rains should follow. It is for this reason that the normal practice is to make applications of Randox just at emergence. Under these conditions the seedling is no longer susceptible to CDAA should any be leached into the root zone. There was a consistent increased reduction of stand with the two higher rates of Randox T in the granular formulation. No consequental interactions between treatments and varieties and soil fungicide-insecticide treatments were apparent.

Weed counts were made 3 weeks after application. Unfortunately severe frosts 10 days after the pre-emergence application froze out the weed seedlings from the untreated areas making comparisons possible on only 1 of the 5 farm sites. Even in these plots, weed populations were extremely low. These results are shown in Table III.

Table III

Weed Counts Following Pre-emergence Application*

	Lambsquarters	Smartweed	Barnyard grass
Randox T 6 qts per A	1.5	2.0	0
9 " " "	1.0	1.5	0
12 " " "	.5	1.0	0
Randox T 42 lbs per A	.5	.5	0
granules 63 " " "	.5	0.0	0
84 " " "	.5	.5	0
Randox(gran.) 30 lbs. per A	.5	2.0	0
Randox 6 qts per A	2.5	2.0	0
untreated control	5.5	8.0	4

* average count 1.0 sq.ft.

Second applications were made on June 7 and 8 on three farm sites. Plants at this time were in the 3 to 4 leaf stage. Prior to the application, all plots were cultivated and hand weeded including the untreated controls. Application rates were identical to the first treatments. The sprays were directed to the base of the plants. Where accidental spray contact on the leaves was made, some burning was noted. Subsequent growth of these injured plants was not impaired and recovery appeared to be complete.

Weed populations were heavy in the untreated controls and most treatments gave very effective control as is shown in Table IV.

Table IV

Weed Counts Following Second Application*

Treatments	Purslane	Smartweed	Barnyard Grass	Other Broadleaves
Randox T 6 qts per A	5.9	12.0	8.1	1.0
9	2.7	12.0	5.7	.5
12	1.3	4.0	4.5	.4
Randox T 42 lbs per A	4.4	30.0	6.4	.7
granules 63 " " "	1.1	8.0	3.3	.3
(35%) 84 " " "	1.1	4.0	1.8	0.0
Randox granules (20%) 30 lbs per A	4.9	32.0	6.2	4.1
Randox spray 6 " " "	9.0	58.0	11.2	6.9
untreated control	58.2	87.0	57.8	24.1

* average number of weeds of 3 test sites based on weed counts per 23 sq.ft.

** lambsquarters
pigweed
Ragweed

Randox is being used extensively on onions but has not given adequate control of smartweed in severely infested areas. This is due in part to the properties of CDAA but also is due to the delayed treatment after seeding which means at least some of the smartweed has emerged and is no longer susceptible to CDAA. Control is usually in the range of 50 to 60% and is borne out in the above results. By virtue of its increased smartweed activity in the Midwest, it was felt that Randox T would serve as a good substitute for growers having a smartweed problem. The results did not confirm this for the pre-emergence application for a yet undetermined reason. However, smartweed control was substantially enhanced with the use of Randox T as compared to Randox following the second application. Randox T at the intermediate application rate gave 85 to 90% control while control with Randox controlled 30 to 60% of the smartweed. The active CDAA equivalent at these concentrations for Randox T and Randox is 6.3 and 6.0 lbs. per acre. It can therefore be assumed that the trichlorobenzyl chloride accounted for the increased smartweed activity.

Third applications were made on July 6 and 7 at comparable rates applied for the earlier treatments. The plots were hand weeded prior to this application. The tops were in the early stages of lodging and therefore uniform coverage with directed sprays was not possible. Granular formulations could be applied more effectively with virtually no leaf burn. The plots were split with one half receiving the 3 applications and the other half receiving 2 applications. Observations 7 weeks later showed a complete cover of weeds on the untreated plots with a predominance of purslane. Randox T at the lowest rate (4.2 lbs CDAA equivalent per acre) gave near perfect control of purslane. Little difference in control could be noted between 2 or 3 applications indicating that the residual activity of the 2nd applications was sufficient for purslane control. Randox at 6 lbs per acre in either the granular or emulsifiable form did not give comparable control even with three applications.

Summary

Randox T at rates of 6 to 9 qts or equivalent rates in granules effectively controlled all weeds except smartweed applied early in the season (1st application). Smartweed control following the 2nd applications is slightly superior to Randox when compared on equivalent CDAA rates with Randox T. Purslane control was markedly superior to Randox.

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INTERACTION OF SOIL MOISTURE, SEED TREATMENT AND HERBICIDES ON ONION STANDS AND YIELDS ON MUCK SOIL

M. W. Meadows[1], J. R. Orsenigo[2], and J. D. VanGeluwe[1]

PROBLEM: The stand of seeded onions on muck soils is often reduced drastically. It is speculated that this stand reduction can be attributed to a number of individual factors or combination effects of several.

Factors that are more usually suspect are herbicide, soil moisture, and insecticide-fungicide seed treatments.

Such variables as planting depth, soil and air temperature, onion variety, etc. may be importamt but were not included in this study.

MATERIALS AND METHODS: A factorial experiment was laid out at the Everglades Experiment Station, Belle Glade, Fla., to check out the following variables.

Soil Moisture (3 levels) - During period of onion germination. Supplemental irrigation was used to supply 0, 1 and 2 inches of additional water.

Herbicide - Pre-emergence applications of 11 herbicidal treatments were made plus 2 untreated checks. The results of 3 granular CIPC ± Randox formulations were combined as were the check treatments.

Seed Treatment - A 5% Ethion-5% Thiram granular was drilled in the row in intimate contact with the onion seed. Rates of application were 0, 40 and 80 lbs. of the granular material per acre based on a 15 inch row spacing. The recommended rate of this granular formulation is 30 lbs. per acre at the same row spacing.

Plots - Individual plots were 40' long x 6' wide consisting of 4 rows of onions spaced 18 inches apart. Two rows received no seed treatment and the remaining rows received the 40 and 80 lb. granular insecticide-fungicide treatment. An individual herbicide treatment was applied over this 40' x 6' plot.

Irrigation treatments were confined to blocks with one block each devoted to a particular water level.

Each seed treatment x herbicide plot within an irrigation block was replicated 4 times.

All planting, spraying and granular application work was done with tractor-mounted equipment.

The following data are pertinent to this work:
Onion variety - Early Yellow Globe
Planting dates - February 4 - 5, 1960
Herbicides applied - February 6, 1960. Sprays in 45 gallons of water per acre and granulars with a Noble applicator.

(1) G.L.F., Soil Building Division, Ithaca, N. Y.
(2) Everglades Experiment Station, Belle Glade, Fla.

Data - Onion stand counts, weed and grass counts, and growth rating - 3/21/60. Total fresh weight of onions; total marketable fresh weight of onions; number marketable green onions; and total number green onions - 5/18-23/60.
Culture to harvest - Post-emergence weed control - 10 lb. KOCN - applied 4/5/60. Hand weeding - 4/11-18/60. 12 lbs./A active CIPC in granular form was applied 4/21.
Soil moisture - At the time that planting was completed the soil was near the saturation point.

RESULTS AND DISCUSSION: Main effects. These results are given in table 1.

Due to the confounding of irrigation treatments, no L.S.D. was calculated for this factor.

Table 1 - Onions - Belle Glade, Florida. Planted 2/4-5/60.
Stand, Yield and Growth Measurements of Onions.
Data for Stand and Growth Taken 3/21/60.
Remaining Data on 5/18-23/60.

Material & Rate	Lbs.	Marketable Fresh Wt.-Lbs./ 5' of Row	Number Marketable/ 5' of Row	Total Fresh Wt.-Lbs./ 5' of Row	Growth Visual (1)	Stand Count/ 5' of Row
Granular Seed Treatment						
5% Ethion-	0	3.07	55.4	3.60	7.99	89.3
5% Thiram	40	2.37	45.4	3.67	7.38	88.5
	80	2.25	42.1	2.77	6.70	79.2
Herbicide Treatments						
Liq. CIPC	6	1.85	39.9	2.42	7.50	86.0
"	12	2.40	48.1	2.90	7.44	87.1
Liq. Randox	6	2.96	51.7	3.47	7.31	83.0
"	12	2.92	48.3	3.37	7.03	76.2
Randox+CIPC Liq.	6+6	2.71	47.7	3.17	6.97	78.1
Randox T Liq.	6	2.74	45.9	3.30	7.22	82.7
Randox T Gran	6	2,75	49.7	3.40	7.44	93.7
Randox Gran	6	2.94	53.0	3.45	7.39	83.7
(2) Randox+CIPC Gran	6+6	2.68	50.1	3.22	7.39	88.5
(3) Checks		2.02	42.3	2.57	7.58	88.8
Irrigation						
No Irrigation		1.90	44.3	2.57	8.07	93.3
1 Inch		3.02	53.9	3.50	7.77	88.2
2 Inch		2.78	44.6	3.20	6.23	75.5
LSD Seed Treatment		0.166**	3.431**	0.697**	0.95**	7.335*
LSD Herbicides		0.399**	2.987**	0.398**	0.306**	5.184**

(1) Growth rating - 1 = no crop; 10 = no damage.
(2) Average of 3 formulations.
(3) Average of 2.
*Significant at 5% level. ** Significant at the 1% level

DISCUSSION:

Seed Treatment - There is some indication that the 40 and 80 lb. levels of seed treatment had a detrimental effect on both number and weight of marketable onions as compared to the untreated check. The 80 lb. rate gave significantly lower values than the 40 lb. rate for all measurements except marketable fresh weight. These results may indicate that disease and insect damage were of minimum importance in this trial.

Herbicides - Of particular note among the herbicide treatments is the reduction in stand count where the excessive rate of 12 lbs. per acre of Randox liquid was used. The remaining plants were able to compensate in yield of both total, and marketable fresh weight.

Liquid CIPC fell down in the yield factors but this can be attributed to competition by a heavy grass population not controlled by CIPC as noted in table 3. The hand weeding operation on 4/11-18 was particularly rough on these treatments.

A tank mix of 6 lbs. CIPC and 6 lbs. Randox liquid spray resulted in stand reductions but here again the remaining population was able to make up the yield differences. Comparing a similar mixture in the granular form there was no significant effect on stand count or yield.

Randox T granular at 6 lbs. per acre gave significantly higher stand counts than any of the other treatments.

The differences noted here could possibly be of greater significance under conditions of low seeding rates. About 6 - 7 lbs. of onion seed were planted per acre in these tests as compared to the usual seeding rate of about 4 lbs. per acre.

Herbicide treatments that tend to reduce stand count could result in reduced yields under low seeding rate conditions.

Irrigation - Due to incomplete randomization of irrigation it would be rather risky to draw any conclusions. It seems pertinent to point out, however, that supplemental irrigation had an adverse effect on onion stands. This thinning out of stand could very possibly have accounted for increased yield of marketable onions especially at the 1 inch irrigation level.

Second and Third Order Interactions - In practically all instances for all measurements of yield there were significant interactions between irrigation x herbicide and irrigation x seed treatment but in no case was there a significant interaction between herbicide and seed treatment.

In most instances yield benefitted by those factors which reduced stand counts with the exception that those onions which received no seed treatment practically always outperformed those which were treated.

The data in table 2 gives the significant third order interaction between the factors studied.

Table 2 - Onion Stand Counts - Belle Glade, Florida. Planted 2/4-5/60. Counts taken 3/21/60. Plants per 5 ft. of row.

Chemical & Lbs. Active/A		Amount of Irrigation 0" Seed Treatment 0	40	80	1" Seed Treatment 0	40	80	2" Seed Treatment 0	40	80
CIPC Liq.	6	102.5	101.0	71.7	80.2	85.7	92.0	75.2	87.0	78.2
CIPC Liq.	12	90.2	107.2	86.2	86.7	85.5	88.2	80.5	82.5	76.5
Randox Liq.	6	94.5	100.2	84.5	86.2	88.0	85.7	71.0	75.5	61.5
Randox Liq.	12	92.5	94.2	76.2	93.0	88.0	71.7	67.7	57.7	44.2
Randox Liq. + CIPC Liq.	6+6	98.5	89.5	81.0	89.0	84.2	70.0	72.7	67.5	50.5
Randox T Liq.	6	103.0	95.7	85.0	83.7	78.5	88.7	79.7	70.7	59.5
Randox T Gran	6	106.2	107.2	87.7	89.5	94.7	95.0	97.0	80.2	85.2
Randox Gran	6	96.5	102.2	76.2	96.0	96.2	80.0	86.0	61.0	58.5
Randox + CIPC Gran (1)	6+6	100.6	100.6	82.4	91.6	92.3	89.1	82.2	81.7	76.2
Check (2)		97.7	101.3	79.4	94.1	87.2	90.1	79.2	85.2	85.0

LSD 5% level = 15.62

(1) Average of 3 formulations.
(2) Average of 2.

DISCUSSION:
Randox liquid, Randox + CIPC liquid, Randox T liquid, and Randox granular reduced stand counts very markedly at the 2 inch irrigation level and 80 lb. seed treatment rate.

It is interesting to note the reduction of onion stand count with Randox T liquid whereas Randox T granular did not reduce stand count. The Randox materials at the higher irrigation level in general reduced onion stand counts when used in conjunction with seed treatments...the herbicide effect being less where no seed treatment was used.

WEED CONTROL:
Under the conditions of this experiment beginning with a soil that was well supplied with water, irrigation had no significant effect on weed control, nor did the seed treatment. Table 3 gives these results.

Table 3- Weed Control in Onions - Belle Glade, Florida. Planted 2/4-5/60. Observations 3/21/60.

Chemical	Lbs. Active Chemical/A	Weeds & Grass per 2 Sq. Ft. Broadleaf Weeds	Grass
CIPC Liquid	6	7.7	107.8
CIPC Liquid	12	6.1	89.2
Randox Liquid	6	4.2	67.7
Randox Liquid	12	3.2	41.2
CIPC + Randox Liquid	6+6	2.6	59.0
Randox T Liquid	6	2.8	79.9
Randox T Granular	6	3.7	96.4
Randox Granular	6	4.4	65.1
Randox + CIPC Granular (1)	6+6	3.6	81.1
Check (2)		7.2	95.7
LSD		2.14**	25.91*

(1) Average of 3 formulations.
(2) Average of 2.
* Significant at the 5% level.
** Significant at the 1% level.

DISCUSSION: Weeds and grasses present were crabgrass (sanguinalis), goosegrass, spiny amaranth and purslane.

The broadleaf weed problem here was not too severe. There are indications that the liquids were superior to granulars in controlling those weeds that were present.

In the control of grasses, liquid formulations containing Randox were superior to CIPC.

Granular Randox was fully as effective as the liquid Randox at the 6 lb. rate for each. The mixing of Randox granular with CIPC granular appears to have decreased the effectiveness of the Randox.

Randox T granular and liquid CIPC were ineffective in reducing grass counts. With Randox T granular there was sufficient suppression of grass growth to give top yields as noted in table 1.

SUMMARY:
In a factorial experiment on seeded muck grown onions, 3 rates of seed treatment, 3 levels of irrigation and 13 herbicidal treatments were studied. Of primary concern was the effect of these treatments on onion stands and yield.

Data recorded was onion stand counts, total fresh weight, total marketable fresh weight, number marketable onions, onion growth rate, broadleaf weed counts and grass weed counts.

The following effects were noted.

1. Seed Treatments - 0, 40 and 80 lbs. of 5% Thiram-5% Ethion granular per acre based on 15 inch rows. Applied with the seed in the drill.
    a. The 40 and 80 lb. seed treatment rates reduced the numbers and total weight of marketable fresh onions. The 80 lb. rate had an adverse effect on all measurements when compared to the untreated check. It is probable that dieeases or insects were of no significant importance in this trial.

2. Herbicides - 13 treatments including 2 untreated checks applied pre-emergence.
    a. Of particular interest is the onion stand reduction resulting from the use of 12 lbs. liquid Randox per acre. Due to a heavy seeding rate the remaining plants were sufficient to produce top yields.
    b. CIPC did not affect onion stand counts but produced low onion yields. This may be attributed to the competition of a heavy crabgrass and goosegrass population that CIPC did not control.
    c. Comparisons of liquid and granular mixtures of CIPC and Randox indicate that the liquid mixture reduced onion stand count whereas the granular mixture did not.

3. Irrigation - 0, 1 and 2 inches additional water applied 2 days after herbicide application.

   Since irrigation levels were not randomized, no valid conclusions could be drawn. The following effects are worthy of note, however.
    a. The 1 and 2 inch levels of irrigation reduced onion stands. This stand reduction resulted in increased marketable yields at the 1 and 2 inch level --- probably due to the elimination of competition between onion plants.

4. Interaction of Seed Treatment, Herbicides and Irrigation on Onion Stand and Yield.
    a. For these measurements there were in most instances interactions for irrigation x herbicide and irrigation x seed treatment. In no instance was there a significant interaction for herbicide x seed treatment.
    b. In general yields were increased by those factors that reduced onion stand count. An exception would be the no seed treatment plots which practically always outperformed the treated areas, in stand count and yields.
    c. Interactions of irrigation x seed treatment x herbicide showed a marked reduction in onion stand at the 2 inch irrigation level where Randox liquid, Randox granular, Randox + CIPC granular and Randox T liquid were used. This effect was noted at all levels of irrigation where 12 lbs. of Randox liquid or 6 lbs. of granular Randox was used in conjunction with the 80 lb. seed treatment rate.
    d. Randox T granular at 6 lbs. had little effect on stand count for the factors studied.

5. Weed Control - Predominantly a grass problem. Under the conditions of this experiment neither irrigation nor seed treatment had any significant effect.
    a. Broadleaf weed control. Liquid formulations in general gave better weed control than granular formulations.
    b. Grass control. Liquid formulations containing Randox were superior to liquid CIPC.
       Liquid and granular Randox were equally effective in reducing grass counts.
       Mixtures of granular Randox and granular CIPC resulted in reduced grass control.
       Randox T granular and liquid at 6 lbs. were not too effective in reducing grass counts. Onion yields indicate, however, that there was enough suppression of grass growth to obtain good onion yields.

PRE-TREATING SOILS, A POSSIBLE TECHNIQUE FOR WEEDING VEGETABLES

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A selective herbicide that will kill a wide range of weed species without danger to the crop, and one whose performance is not unduly influenced by either soil or environment, is the goal of many workers. Obviously, there are very few such chemicals available at present for weeding vegetable crops. Thus, there is a need for additional techniques by which weeding can be accomplished safely without resorting to costly hand labor.

The purpose of this report is to present a few limited research results regarding the feasibility of pre-planting chemicals treatments for several vegetable crops.

Experimental

In a series of preliminary tests on sandy loam soil, certain individual plots from earlier treatments were utilized by replanting the initial crop. The plots chosen had given excellent weed kill but had seriously damaged or killed the first planting. The soil was raked by hand just prior to the second planting. A summary of these preliminary test results is presented in Table 1. From these observations, it was clear that several chemicals having high initial weed killing ability, but which injured crops, might possibly be rendered non-toxic in a sufficiently short period of time to warrant their use as pre-planting treatments.

As a partial follow-up of these results, greenhouse tests are being conducted with 7442 and 8043 to determine if possible the specific length of time they remain toxic. Rates of 4 and 6, and 2 and 4 pounds for 7442 and 8043 respectively were sprayed on flats filled 2" deep with greenhouse potting soil. One series was planted immediately to timothy and broccoli. A duplicate series was planted at weekly intervals for four successive weeks. Hercules 8043 lost its toxic action in approximately three weeks. However, 7442 still showed toxicity in the fifth planting.

A field test was conducted in which plantings of several vegetables were made at time of treating and at one and two weeks later. The individual plots were 6' x 15' and each contained spinach, cabbage, lettuce, carrots and tomatoes. A separate series was used for each planting date. There were two replications. Crop response and control of weeds were rated approximately six weeks after the first planting. In general, weed control was excellent for all materials. However, galinsoga was prevalent and this pest was not controlled by either EPTC or St. 2061. The plots were not re-worked between the initial treatment and the subsequent plantings.

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Table 1. Results from re-planting plots which had given excellent initial weed kill and severe initial crop damage.

Chemical		Lbs.	Replanted Crop Response[1/]			
			Broccoli	Cabbage	Lettuce	Spinach
1. Dacthal		6	sel.	sel.	8.5	8.0
2. "		8	sel.	sel.	8.5	8.0
3. Hercules	7175	2	1.0	1.0	1.0	6.0
4. "	"	3	1.0	1.0	1.0	4.0
5. "	7442	4	7.5	7.5	8.0	7.0
6. "	"	6	4.5	4.5	7.0	8.0
7. "	8043	2	9.0	9.0	8.0	7.0
8. "	"	3	9.0	9.0	8.5	8.0
9. Niagara	5996	1	-	-	1.0	1.0
10. "	"	2	-	-	1.0	1.0
11. Amiben		4 gran.	9.0	9.0	-	-

1/ Soil raked and crops replanted 33 days after initial treatment and planting.
Sel.= selective on these crops initially
9 = perfect growth; 7 = acceptable; 5 = stunting; 1 = kill.

Data on crop responses are presented in Table 2. It can be seen that with the two Stauffer materials delayed planting had a marked influence on crop response. Practically all toxicity from the two pound rates of EPTC and 2061 was eliminated after two weeks. The higher rates still showed some toxicity. Soil moisture during the treatment and planting period averaged higher than normal because rainfall was substantial following a heavy early irrigation. This might have increased the rapidity of breakdown or degree of leaching. However, the Niagara and Hercules compounds retained much of their initial high levels of toxicity even after two weeks.

A third test was conducted on the same sandy loam soil. Only two compounds were included, EPTC and St. 2061. Two rates of each were worked into the soil either by raking or by disking. Six plantings of beets and spinach were made at approximately three day intervals following treating. Ratings of crop responses were made approximately seven weeks following treating. Results from this test were difficult to interpret because galinsoga was present in varying amounts throughout the experimental area. Neither EPTC nor St. 2061 gave control, thus later crop plantings were at a serious competitive disadvantage. This resulted in stunted plants. However, based on initial stands, it appeared that the previously mentioned general trend of reduced toxicity with EPTC and 2061 after ten to fourteen days also held in this test.

Table 2. The influence of delayed planting on crop response to several chemicals

Chemical	Lbs.	Weeks Elapsed	Crop Response1/ Spinach	Cabbage	Lettuce	Carrots	Tomatoes
1. EPTC	2 (gran.)	0	1.0	2.0	1.5	3.5	2.0
		1	1.0	2.0	1.0	3.5	5.5
		2	1.0	9.0	8.5	9.0	7.5
2. EPTC	4 (gran)	0	1.0	1.0	1.0	2.5	1.0
		1	1.0	1.5	1.5	3.0	3.0
		2	5.5	7.5	6.0	7.0	4.5
3. Stauffer 2061	2 (gran)	0	7.0	1.0	1.5	4.5	8.0
		1	7.0	1.0	2.2	4.0	8.5
		2	7.5	8.0	8.0	9.0	9.0
4. Stauffer 2061	4 (gran)	0	1.0	1.0	1.0	2.5	1.0
		1	5.5	1.0	1.5	3.5	8.0
		2	5.5	5.5	3.5	7.0	8.0
5. Niagara 5996	2	0	1.0	1.0	1.0	1.0	1.0
		1	1.0	1.0	1.0	1.0	1.0
		2	1.0	1.0	1.0	1.0	1.0
6. Niagara 5996	4	0	1.0	1.0	1.0	1.0	1.0
		1	1.0	1.0	1.0	1.0	1.0
		2	1.0	1.0	1.0	1.0	1.0
7. Hercules 7175	1	0	1.0	1.0	1.0	1.5	1.0
		1	1.0	1.0	1.0	1.0	1.0
		2	2.0	1.0	1.0	1.0	1.0
8. Check*			7.0	8.0	7.0	7.0	7.5

1/ Crop response of 9 = perfect growth; 7 = acceptable; 5 = stunting; 1 = kill.
* Check plot crops were somewhat stunted due to weed competition.
All chemical treatments gave good to excellent weed control

Discussion and Summary

The need for additional techniques of obtaining weed control in vegetables without resorting to costly hand labor will continue to be great until consistently safe and effective selective herbicides are available. The authors suggest that one possibility might be pre-treating with chemicals that have a high initial toxicity and a short residual period.

Some of the chemicals tested such as EPTC and St. 2061, also Hercules 8043 and 7442, may possibly prove to be satisfactory. However, many additional compounds need to be tested in this manner. Also, there needs to be considerable work on the influence of soils and environment on breakdown of the chemical. A very practical question as yet unanswered is the extent to which the soil can be re-worked between initial treating and planting.

It is hoped that other workers will assist in investigating this possible technique.

Progress Report on Weed Control in Beets, Carrots, Snap Beans and Sweet Corn

W. J. Saidak[1]

Chemical weed control trials in certain vegetable crops were conducted at Ottawa in 1959 and 1960. These trials were designed to compare promising new materials with the herbicides currently recommended by the Eastern Section of the Canadian National Weed Committee. Particular attention was paid to the effect of treatments on yield, the duration of the weed control period and the reliability from year to year.

The experimental design used for each trial was a randomized complete block with 4 replications. Minimum plot size for beets, carrots and snap beans was 3 rows each 25 ft long, while minimum plot size for sweet corn was 2 rows each 25 ft long. All crops were planted in rows 3 ft apart. Cultivation during the growing season was limited to the center 2 ft between rows. The sandy loam soil used was dragged and rolled before planting.

All liquid chemicals were applied using a CO_2 powered plot sprayer at a pressure of 25 psi and in a water volume of 48 gpa. Granular herbicides were diluted with white silica sand and distributed by hand.

The predominant weeds in the area used for the trials were: common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), barnyard grass (*Echinochloa crusgalli* (L.) Beauv.), common purslane (*Portulaca oleracea* L.), Pennsylvania smartweed (*Polygonum pensylvanicum* L.), witchgrass (*Panicum capillare* L.), field bindweed (*Convolvulus arvensis* L.) and shepherdspurse (*Capsella bursa-pastoris* (L.) Medic.)

Beets Detroit Dark Red beets were planted on May 16, 1960. Treatments which were incorporated pre-planting were applied immediately prior to seeding; the pre-emergence treatments were applied immediately after seeding. The predominant weeds in the control plots were common lambsquarters and redroot pigweed as well as some barnyard grass, common purslane and Pennsylvania smartweed. The marketable yield of beets and fresh weight of weeds obtained from the center 20 ft of the middle row in each plot are presented in Table 1. These data were recorded on July 19 and 20.

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Table 1. Mean marketable yield of beets (lb/20 ft of row) and mean fresh weight of weeds (lb/20 ft of row) following treatment with different herbicides.

Herbicide	Rate (lb/A)	Beet Yield	Herbicide	Rate (lb/A)	Weed Wt
Control HW [4]		15.1 [2]	Control HW		----
CDEC	8	13.9	R.2061	6 (i)	3.1
R.2061	6 (i) [3]	10.1	R.2061	4 (i)	5.3
R.2060	6 (i)	9.9	CDEC	8	5.4
R.2060	4 (i)	8.1	CDEC	5	8.0
R.2061	4 (i)	7.8	R.2060	4 (i)	12.5
CDEC	5	6.0	R.2060	6 (i)	12.8
Endothal	12	3.7	Endothal	8 (i)	13.8
Endothal	8 (i)	2.8	Endothal	8	15.4
Endothal	8	2.4	Endothal	12	16.1
Endothal	12 (i)	2.2	Endothal	12 (i)	16.8
Endothal + TCA	8 + 8	1.3	TD-62	8	18.9
Control BC [5]		0.7	Endothal + TCA	8 + 8	19.1
TD-62	8	0.6	Control BC		25.5

With the exception of CDEC at 8 lb/A, all treatments resulted in marketable beet yields significantly lower than the hand weeded control. Some stunting of beet seedling growth was observed, but this did not influence final yields obtained. Previous trials at Ottawa have indicated that CDEC provides questionable commercial weed control. Nevertheless, of the herbicides evaluated to date, CDEC has provided the most effective control of annual broadleaved weeds.

[2] Treatments that are grouped by vertical lines are not significantly different, using Duncan's test.

[3] (i) Chemicals incorporated with a rototiller prior to planting, other chemicals pre-emergence.

[4] HW - hand weeded

[5] BC - band cultivated

Endothal as a pre-planting incorporated treatment provided very disappointing weed control, in contrast to the excellent results obtained with this application method in 1958. This herbicide applied pre-emergence has always been ineffective at Ottawa. The addition of TCA to the pre-emergence application of endothal provided excellent control of annual grasses, this was presumably due to the effect of TCA.

The EPTC analogues R.2060 and R.2061 were less harmful to beets than EPTC, but R.2060 was not a satisfactory herbicide at the rates used, while R.2061 injured the beets.

Carrots Red Cored Chantenay carrots were planted on May 12, 1960. Chemicals were applied immediately after planting or post-emergence on June 2, when the carrots were in the first true leaf stage and the weeds were 2 to 3 in high. The weeds presented in the control plots were common lambsquarters, barnyard grass, common purslane, redroot pigweed, and shepherdspurse. Table 2 contains the marketable yield of carrots and fresh weight of weeds which were obtained from 25 ft of the middle row in each plot on August 11 and 12.

Table 2. Mean marketable yield of carrots (lb/25 ft of row) and mean fresh weight of weeds (lb/25 ft of row) following treatment with different herbicides.

Herbicide	Rate (lb/A)	Carrot Yield	Herbicide	Rate (lb/A)	Weed Wt
Amiben (L)[6]	4	28.6	Amiben (L)	4	2.0
Amiben (G)	4	25.0	Amiben (G)	4	2.4
Solan	4 (ii)[7]	22.9	Prometone	4	3.8
Dicryl (L)	3 (ii)	20.0	Dicryl (L)	3 (ii)	6.5
CIPC	6	19.6	Dicryl (L)	4 (ii)	6.6
Solan	3 (ii)	18.9	Solan	4 (ii)	10.2
Dicryl (L)	4 (ii)	18.1	Varsol	80 gpa (ii)	11.5
Varsol	80 gpa (ii)	17.4	CIPC	6	12.3
Dacthal	8	14.5	Zytron (G)	15	14.4
CIPC	4	13.8	Dacthal	8	15.8
Zytron (G)	15	12.6	Solan	3 (ii)	17.8
Dicryl (G)	4	----	CIPC	4	23.3
Prometone	4	----	Dicryl (G)	4	32.8
Control BC		----	Control BC		41.8

6(L) liquid formulation, (G) granular formulation.

7(ii) chemical applied post-emergence, other treatments applied pre-emergence.

Carrot yields are not presented in Table 2 for the band cultivated control and granular dicryl treatments, because weed competition in these plots was sufficiently intense to prevent the development of any marketable carrots. Prometone, completely inhibited carrot seed germination.

The most promising treatment in this trial was liquid or granular amiben which resulted in carrot yields significantly higher than the currently recommended varsol treatment. Amiben performance in the 1959 carrot trial was rather mediocre. Meteorological data for both years indicates that rainfall after application may be the reason for the variable performance. In 1959, no precipitation occurred until 7 days after amiben application when 0.3 in were recorded, while in 1960 0.7 in were recorded shortly after application and 0.8 in were recorded in the following week. Another possible explanation could be that in 1959 amiben application was made 5 days after planting, while in 1960 it was applied immediately after planting.

For the past 2 years, CIPC at rates of 6 to 8 lb/A has given effective weed control during the early part of the season. The main disadvantage of this chemical appeared to be its short residual weed control period.

Dicryl and solan were promising selective herbicides for carrots in this trial. Dicryl was a more effective weed killer at the rates used than was solan. Barnyard grass was the predominant weed not controlled by these herbicides.

Snap Beans Pre-planting incorporated herbicide treatments were applied on May 27, 1960. The following day, Tendergreen snap beans were planted in the experimental area. Pre-emergence treatments were applied immediately after planting, and post-emergence treatments were applied on June 4 when the beans were mainly in the 2 leaf stage. The post-emergence treatments were scheduled for application shortly after bean emergence but unsuitable weather conditions for spraying necessitated the delay. The weed population consisted mainly of common lambsquarters, redroot pigweed, common purslane, field bindweed, field horsetail and barnyard grass. The fresh weed weight and marketable bean yield data presented in Table 3 were obtained from 25 ft of the middle row in each plot. The weed weight data were obtained at the time of the final bean harvest on August 2.

EPTC and R.2061 pre-planting incorporated and liquid or granular amiben pre-emergence were the outstanding treatments evaluated in this experiment. Amiben was a much more effective herbicide in 1960 than in 1959.

DNBP 6 lb/A liquid or granular and CIPC 6 lb/A pre-emergence treatments produced excellent early season weed control. However, inadequate weed control was observed during the harvesting period which has been a constant shortcoming of these treatments.

Considerable bean stunting was observed after the post-emergence application of DNBP and DNBP combined with CDEC or CDAA. These treatments applied at emergence in 1959 gave excellent weed control. This suggests that application timing may be one of the critical factors preventing the general use of this treatment.

The Niagara 5996 chemical appeared to lack sufficient selectivity at a rate which would give adequate weed kill.

Table 3. Mean marketable yield of snap beans (lb/25 ft of row) and mean fresh weight of weeds (lb/25 ft of row) following treatment with different herbicides.

Herbicide	Rate (lb/A)	Bean Yield	Herbicide	Rate (lb/A)	Weed Wt
R.2061	4 (i)	15.3	Control HW		----
Control HW		14.7	N.5996	4	0.8
EPTC	4 (i)	14.4	Amiben (L)	4	0.8
Amiben (L)	4	14.4	EPTC	4 (i)	0.9
CIPC	6	14.3	Amiben (G)	4	1.4
N.5996	2	13.3	R.2061	4 (i)	1.6
Amiben (G)	4	12.9	DNBP + CDEC	3 + 3 (ii)	2.1
DNBP (L)	3 (ii)	12.5	DNBP (L)	3 (ii)	2.2
DNBP (L)	6	11.9	DNBP + CDAA	3 + 3 (ii)	3.7
DNBP (G)	6	11.9	CIPC	6	4.1
DNBP + CDAA	3 + 3 (ii)	10.5	DNBP (L)	6	4.6
DNBP + CDEC	3 + 3 (ii)	9.9	N.5996	2	5.5
N.5996	4	9.1	DNBP (G)	6	6.5
Control BC		8.2	Control BC		16.4

Sweet Corn Seneca Arrow sweet corn was planted on May 27, 1960. Herbicides were applied pre-emerbence shortly after planting and post-emergence on June 7 when the corn was in the 2 to 3 leaf stage. Rainfall totalled 1.7 inches in the week following the application of the pre-emergence herbicides. The weed population was comprised mainly of redroot pigweed, common purslane and common lambsquarters with a small population of barnyard grass, witchgrass and field bindweed. The corn received a single irrigation on July 28 when, 1 in of water was applied. Yield data and weed fresh weight data presented in Table 4 are based on 2 rows each 25 ft long. The weed weight data were obtained shortly after the final corn harvest on August 24.

For the past 2 growing seasons non-significant yield differences have been obtained between the simazine pre-emergence, atrazine, pre or post-emergence, 2, 4-D post-emergence, and DNBP pre or post-emergence treatments. In both years excellent growing conditions for sweet corn were prevalent and supplemental irrigation was applied when required. In addition, a small annual grass population has prevented the detection of any differences in annual grass control between 2, 4-D and simazine or atrazine. Rainfall has been more than adequate after pre-emergence applications of simazine and atrazine minimizing any possible differences in weed control effectiveness between these compounds.

The 1960 trial indicated that there was no significant difference in weed control between granular or wettable powder formalations of simazine or atrazine at the 2 lb/A rate.

Table 4. Mean marketable yield of sweet corn (lb/50 ft of row) and mean fresh weight of weeds (lb/50 ft of row) following treatment with different herbicides.

Herbicide	Rate (lb/A)	Corn Yield	Herbicide	Rate (lb/A)	Weed Wt
Atrazine	2	63.4	Control HW		----
Atrazine	2 (ii)	56.3	Atrazine	2	0.4
Atrazine (G)	2	56.1	Atrazine (G)	2	0.6
2, 4-D Amine	0.5 (ii)	54.5	Atrazine	2 (ii)	1.5
Simazine	2	53.7	Simazine	2	2.3
Control HW		52.2	Simazine (G)	2	3.1
Simazine (G)	2	52.1	DNBP	6	3.9
DNBP	6	52.1	DNBP	3 (ii)	4.3
DNBP	3 (ii)	51.7	2, 4-D Amine	0.5 (ii)	5.8
Control BC		34.5	Control BC		27.9

SUMMARY

Although CDEC was the most effective herbicide evaluated for annual broad leaved weed control in beets, it provided questionable commercial weed control. Excellent annual grass control was obtained using TCA pre-emergence. At present, these chemicals are the only recommended selective herbicides for use in beets in Eastern Canada. A more effective annual broadleaved weed herbicide than CDEC is still required for this crop.

Liquid or granular amiben was the outstanding herbicide evaluated in the 1960 carrot trial. Further studies are required with amiben in order to determine the factor or factors responsible for its variable performance. CIPC is worthy of consideration as an alternative recommendation to the current varsol recommendation. Dicryl and possibly solan should be included in the 1961 carrot herbicide trial.

Pre-planting incorporated EPTC and R.2061 and pre-emergence amiben provided excellent weed control in snap beans for the entire growing season, but require further evaluation. The present CIPC or DNBP pre-emergence and DNBP at emergence recommendations provide inadequate residual weed control, do not control annual grasses and are not reliable. The DNBP at emergence treatment may reduce yields if application is delayed.

Comparison of simazine, atrazine, 2,4-D and DNBP in irrigated sweet corn with a small population of annual grasses resulted in non-significant yield differences for the past two growing seasons. Pre or post-emergence atrazine and post-emergence DNBP should receive consideration as recommendations in sweet corn, to supplement the present 2,4-D, simazine and DNBP recommendations.

Chemical Weed Control in Carrots

Charles J. Noll[1]

In 1959 several herbicides treatments looked promising for the weeding of carrots in addition to the recommended chemical Stoddard Solvent. The experiment reported in this paper is a continuation of last years work.

Procedure

The variety Chantenay Red Cored was seeded May 2, 1960. The pre-emergence treatments were applied 2 or 5 days after seeding and the post-emergence treatments were applied 32 days after seeding at the time the carrots had their first true leaves. Individual plots were 28 feet long and 2 feet wide. Treatments were randomized in each of 8 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. The growing season was cooler than average and rainfall below normal. An estimate of weed control was made June 30 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Carrot harvest was completed October 19.

Results

The results are presented in Table 1. All chemicals gave highly significant increases in weed control as compared to the untreated check. Two chemicals, Solan and Karsil at all rates gave highly significant increases in weed control as compared to the Stoddard Solvent treated plot.

Three chemicals, Stoddard Solvent, Dicryl and CIPC, significantly reduced the stand of carrots as compared to the untreated check plots. No treatment significantly increased the stand of plants as compared to the untreated check plot.

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Yields from the Stoddard Solvent plots were more than twice that of the untreated plot. Other treatments giving similar yield were Dicryl at 4 lbs. per acre, Dacthal at 6 and 9 lbs. per acre and Zytron at 10 and 15 lbs. per acre. Two chemical treated plots gave yields significantly larger than the Stoddard Solvent treated plot. These treatments were Solan applied at 6 and 8 pounds per acre and Karsil applied at 4 pounds per acre.

Although treatments in 1960 were not all duplicates of treatments in 1959 the greatest yield in both years was where Solan was applied at the time carrots had their first true leaves at a rate of 6 pounds per acre.

Conclusion

A number of chemicals look promising in comparison to Stoddard Solvent our recommended practice for the weeding of carrots. The best treatments were Solan and Karsil applied at time carrots had their first true leaves. Solan looks especially promising for the weeding of carrots applied at the rate of 6 pounds per acre.

Table I. Weed control, plant stand and weight of marketable carrots under chemical herbicide treatment.

Chemical	Active Rate Per Acre lbs.	Days from Seeding	AVERAGE PER PLOT Weed* Control (1-10)	Stand of Plants	Wt. of Marketable Roots, lbs.
Nothing	--	--	10.0	459	11.3
Stoddard Solvent	70 gal.	32	2.4	397	27.5
Solan 4512	4	32	1.1	487	34.6
" "	6	32	1.0	475	39.1
" "	8	32	1.0	461	36.3
Dicryl 4556	4	32	1.5	361	28.5
" "	6	32	1.5	205	19.4
" "	8	32	1.1	99	10.5
Karsil 4562	4	32	1.0	509	36.8
" "	6	32	1.0	492	32.6
Amiben	2	2	6.4	479	17.8
"	3	2	6.6	444	20.4
Dacthal 893	6	2	3.0	489	27.3
" "	9	2	3.3	501	28.0
CIPC	4	2	2.8	401	24.8
"	6	2	3.4	323	16.7
Zytron M1329	10	5	2.3	504	33.4
" "	15	5	3.5	492	25.9
Least Significant Difference (P=.05)			1.0	51	8.2
" " " (P=.01)			1.3	68	10.8

*Weed control 1-10: 1 Perfect weed control
10 Full weed growth

Chemical Weed Control in Snap and Lima Beans

Charles J. Noll[1]

Earlier work at a number of institutions including Penn State University suggested that lima beans and snap beans respond differently to the same herbicides. To further study this difference and to investigate newer chemicals for the weeding of these crops the following experiment was conducted.

Procedure

The lima bean variety Fordhook 242 and the snap bean variety Improved Tendergreen were seeded June 7. Each plot consisted of a single run of 25 feet of lima beans and 11 feet of snap beans planted 3 feet apart. Pre-planting treatments were applied the day before seeding and incorporated in the soil. All other treatments were applied either the day following planting or 2 days after planting. Treatments were randomized in each of 6 blocks.

The pre-planting treatments and the granular herbicides were applied over the row for a width of 2 feet. All other applications were sprayed over the row for a width of 1 foot. Cultivation controlled the weeds between the rows. An estimate of weed control was made August 10 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Snap bean harvest was completed August 8 and lima beans harvested September 28.

Results

The results are presented in tables I and II. All chemicals gave highly significant increases in weed control as compared to the untreated check. Many chemicals gave near perfect weed control at all rates. These include the two pre-planting treatments EPTC and R-2061 and the pre-emergence treatments Amiben, Propazine, Atratone, Trietazine and Alanap 3. Other treatments that gave excellent weed control were Fenac at 1 1/2 lb. per acre, Zytron at 18 lbs. per acre, Niagara 5996 at 6 lbs. per acre and DNBP at 6 lbs. per acre in a Pre-emergence treatment.

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The stand of plants of both lima bean and snap bean was significantly reduced as compared to the untreated check by Fenac, Propazine, Atratone and Niagara 5996. The chemicals CIPC and Alanap 3 reduced the stand of lima beans but did not reduce the stand of snap beans.

Snap bean yield was significantly better than the check or any other treatment where DNBP was applied at 4 lbs. per acre 2 days after seeding. Many other treatments were equal to the untreated check.

Chemically weeded lima bean plots were significantly better in yield than the untreated check plot where the following chemicals were applied. Amiben at 4 lbs. per acre, Zytron at 12 and 18 lbs. per acre, Trietazine at 4 and 6 lbs. per acre, Hercules 7442 at 4 and 6 lbs. per acre, Dacthal at 6 and 9 lbs. per acre, DNBP Granular at 3 lbs. per acre and DNBP liquid at 4 and 8 lbs. per acre.

Conclusion

Snap beans and lima beans do vary in their response to various chemicals as shown by the stand and yield records. A number of chemicals look promising for the weeding of lima beans in addition to our recommended chemical DNBP. Snap bean yields were best in the DNBP treated plot.

Table I. Weed control, plant stand and weight of marketable snap bean under various herbicide treatments.

Chemical	Active Rate /A lbs.	When Applied Days from Seeding	AVERAGE PER PLOT Weed* Control (1-10)	Stand of Plants	Wt. of beans in pods lbs.
Nothing	--	--	8.2	108	5.8
°Eptc	6	-1	1.3	115	5.6
° "	9	-1	1.0	114	3.9
°R-2061	6	-1	1.2	109	5.4
"	9	-1	1.3	112	5.2
Fenac	1	1	2.5	56	0
"	1½	1	1.7	35	0
Amiben	4	1	1.2	111	5.7
"	6	1	1.5	113	4.7
CIPC	6	1	3.0	95	5.7
"	9	1	2.8	80	5.3
Zytron	12	1	2.7	106	6.9
"	18	1	1.5	113	6.4
Propazine (G30028)	2	1	1.8	3	0
" "	3	1	1.3	1	0
Atratone (G32293)	4	1	1.2	55	1.4
" "	6	1	1.2	18	.4
Trietazine (G27901)	4	1	1.5	102	3.7
" "	6	1	1.2	69	1.7
Hercules 7442	4	1	5.0	114	6.5
" "	6	1	3.7	111	5.4
CDEC (Vegadex)	6	1	7.2	116	6.9
" "	9	1	4.8	116	5.9
NPA (Alanap 3)	8	1	2.3	52	.5
" "	12	1	1.8	45	.3
Dactal 893	6	1	4.2	110	6.4
" "	9	1	3.3	105	5.9
Niagara 5996	4	1	2.8	88	5.6
" "	6	1	1.2	25	1.9
DNBP(Premerge)10%Gran.	3	2	3.3	111	6.5
" " "	6	2	2.2	99	4.2
DNBP(Premerge)	4	2	4.8	113	7.4
" "	8	2	3.7	115	6.6
2,4-D (Amine)	1	2	5.5	112	4.2
" "	2	2	5.0	101	1.7
Least Significant Difference 5%			1.4	17	1.2
" " " 1%			1.8	23	1.5

*Weed Control 1-10: 1 Perfect Weed Control: 10 Full Weed Growth
°Soil incorporation prior to planting.

Table II. Weed control stand and weight of lima beans - the pod under various herbicide treatments.

Chemical	Active Rate /A lbs.	When Applied Days from Seeding	AVERAGE PER PLOT Weed* Control (1-10)	Stand of Plants	Wt. of beans in pods lbs.
Nothing	--	--	8.2	71.5	7.8
°EPTC	6	-1	1.3	6.0	.3
° "	9	-1	1.0	.5	0
°R-2061	6	-1	1.2	55.8	5.4
° "	9	-1	1.3	31.2	2.8
Fenac	1	1	2.5	21.8	1.3
"	1½	1	1.7	5.2	.1
Amiben	4	1	1.2	82.3	11.8
"	6	1	1.5	76.3	7.3
CIPC	6	1	3.0	79.5	9.6
"	9	1	2.8	72.0	9.5
Zytron	12	1	2.7	80.5	11.5
"	18	1	1.5	77.5	12.0
Propazine (G30028)	2	1	1.8	54.7	3.3
" "	3	1	1.3	28.2	.9
Atratone (G32293)	4	1	1.2	58.3	7.5
" "	6	1	1.2	37.7	3.5
Trietazine (G27901)	4	1	1.5	77.0	11.6
" "	6	1	1.2	78.0	10.9
Hercules 7442	4	1	5.0	78.8	10.2
" "	6	1	3.7	79.2	10.4
CDEC (Vegadex)	6	1	7.2	77.2	8.2
" "	9	1	4.8	81.2	8.9
NPA (Alanap 3)	8	1	2.3	73.5	8.5
" "	12	1	1.8	73.0	6.9
Dacthal 893	6	1	4.2	79.5	10.9
" "	9	1	3.3	82.0	10.2
Niagara 5996	4	1	2.8	51.8	9.7
" "	6	1	1.2	7.7	1.4
DNBP(Premerge)10%Gran.	3	2	3.3	82.8	12.5
" " "	6	2	2.2	73.3	8.7
DNBP (Premerge)	4	2	4.8	78.5	10.3
" "	8	2	3.7	79.2	10.5
2,4-D (Amine)	1	2	5.5	65.0	5.4
" "	2	2	5.0	55.7	4.7
Least Significant Difference 5%			1.4	13.1	2.6
" " " 1%			1.8	17.3	3.4

*Weed Control 1-10: 1 Perfect Weed Control: 10 Full Weed Growth
° Soil incorporation prior to planting.

Chemical Weed Control in Tomatoes

W. J. Saidak and W.M. Rutherford[1]

Abstract

Chemical weed control experiments in transplanted tomatoes were conducted in 1959 and 1960 at the Central Experimental Farm, Ottawa, and the Experimental Farm, Smithfield, Ontario. The variety Fireball was used for the Ottawa trials, while the variety Ferguson was used at Smithfield. The weed population at both locations was dominated by broadleaved annual weeds.

The granular herbicides evaluated in 1959 were: amiben, CDEC, DNBP, EPTC, simazine, CIPC and neburon. These chemicals were applied pre-emergence to the weeds, two weeks after transplanting. Solan was applied as a post-emergence spray to weeds less than 3 inches high one month after transplanting. Amiben, solan, and CDEC were selected for further evaluation in 1960 on the basis of weed control effectiveness determined by fresh weed weights, and lack of crop injury determined by marketable yields.

In 1960, comparison was made between single and double applications of amiben, solan and CDEC. These treatments had no significant effect on yield. The duplicate applications provided significantly better weed control than the single applications at Smithfield, but differences were not significant at Ottawa where the weed population was smaller. Pre-planting incorporation of amiben and CDEC resulted in a significant reduction in the weed killing ability of these chemicals.

In these experiments solan and amiben at 4 and 6 lb/A have produced reliable and effective weed control, while CDEC resulted in less reliable weed control.

[1]Research Officers, Canada Department of Agriculture, Plant Research Institute, Ottawa and Experimental Farm, Smithfield, respectively.

EFFECT OF SEVERAL HERBICIDES ON EARLY YIELD AND PLANT GROWTH OF VALIANT TOMATOES

Peter C. Rogers and Oscar E. Schubert[1]

Each year weed competition costs farmers considerable money by decreasing yield and increasing the costs of production. Any herbicide that will increase the efficiency of weed control without appreciable injury to the plant or excessive cost is desirable. In 1959, O. E. Schubert and N. C. Hardin (1) tested several herbicides on tomato plants. The experiment described in this paper was planned to recheck the more effective treatments and combinations of these. The herbicides were applied to established tomato transplants grown in the field to determine their effectiveness in weed control, the extent of the injury to the tomato plants, and the yield of fruit.

MATERIALS AND METHODS

The experiment was conducted at the West Virginia University Horticulture Farm on a heavy clay loam. Valiant tomato plants were grown in 2 1/2" wood veneer bands before they were set out in the field on May 21. Each plot was 9 feet wide and 12 feet long and contained 4 plants. There were eight replications of twelve treatments each. These treatments are given in Table 1.

The first herbdides were applied on June 7, the day of the last cultivation. These treatments were all pre-emergent granulars and were applied as evenly as possible with a salt shaker having large holes. A follow-up spray application was made on some plots at the weed height optimum for the application of Solan. This height, 1-1 1/2", was reached on June 22, and the plots were sprayed the same day. Also another spray, a combination of Solan and Simazine, was applied at this time with the intent of killing and checking further growth of the weeds. The treatments were applied in water at the rate of 1 quart per plot or 100 gallons per acre at 75 pounds pressure by the use of a power sprayer with a weed nozzle.

RESULTS AND DISCUSSION

Early, marketable and total yields of tomatoes are shown in Table 2. Where Simazine 80W + Solan was applied the plants were significantly more productive than all the other treatments except the hoed check in both early (all fruit harvested by August 11) and total yields (all fruit harvested by August 18). The plants in the hoed check plots had significantly greater early production than those in Amiben plots followed by Simazine 80W + Solan. In total yield the plants in the hoed check plots

[1]Graduate student and Associate Horticulturist, West Virginia University.

Table 1. Herbicide treatments applied to established Valiant tomato transplants.

Treatment number	Treatment applied June 7, 1960			Treatments applied as a spray to surface on June 22, 1960	
	Treatment and formulation	Rate[a] a.i. lb/A	Type of application	Treatment and formulation	Rate[a] a.i. lb/A
1	Amiben 10G[b]	4	Surface	Simazine 80W[c] Solan 4EC[d]	1 4
2	Check (not hoed or cultivated after June 7)				
3	Eptam 5G	4	Raked into soil 1 1/2"	Solan 4EC	4
4	Simazine 4G	1 1/2	Surface		
5	Amiben 10G	4	Surface		
6	Eptam 5G Amiben 10G	3 3	Raked into soil 1 1/2" Surface		
7	None at this time			Solan 4EC	4
8	Amiben 10G Eptam 5G	4 3	Surface Raked into soil 1 1/2"	Solan 4EC	4
9	Amiben 10G	3	Surface		
10	None at this time			Simazine 80W Solan 4EC	1 4
11	Eptam 5G	6	Raked into soil 1 1/2"		
12	Hoed as often as needed for weed control thoughout the season				

a Active ingredient in pounds per acre.
b 10 percent granular.
c 80 percent wettable.
d 4 pounds per gallon, emulsifiable concentrate

were more productive than all the other treatments except Simazine + Solan. The plants with the Simazine 80W + Solan treatment had a sigificantly greater marketable production (all marketable fruit harvested by August 18) than all the other treatments.

Results for weed weights, both grasses and broad-leaved, are shown in Table 3. In the following discussion about weeds the hoed check will not be taken into consideration because the weeds were removed by cultivation during the season. All the treatments significantly reduced the stand of grasses except in the treatments where Simazine 4G or Solan were used albna. Eptam plots had significantly more broad-leaved weeds than all the other treatments except the nonhoed and the Simazine 4G plots.

Table 2. Calculated acre yields of Valiant tomatoes receiving various herbicide treatments.

Treatment number	Treatments		Yield in pounds		
	Applied June 7	Applied June 22	Total early to August 11	Marketable to August 18	Total[a] to August 18
1	Amiben	Simazine 80W Solan	6,736	8,082	19,497
2	Check		7,409	7,386	21,463
3	Eptam	Solan	7,386	8,384	21,637
4	Simazine 4G		7,356	9,117	24,691[e]
5	Amiben		8,263	9,382	24,313
6	Eptam Amiben	Solan	7,590	8,823	26,271[e]
7		Solan	8,097	9,337	26,437[e]
8	Amiben	Solan	7,658	7,938	25,266[e]
9	Eptam Amiben		8,550	9,699	26,263[e]
10		Simazine 80W Solan	11,189[b]	14,273[d]	34,428[be]
11	Eptam		7,764	10,221	26,090[e]
12	Hoed check		9,489[c]	10,282	31,858[ef]

[a] The plants were picked clean of all fruit on the last day of harvest August 18. The total includes all the fruit picked from the first day of harvest, July 8, to the last day, August 18.
[b] Significantly better than all treatments except 12 at 5% level.
[c] Significantly better than treatment 1 at 5% level.
[d] Significantly better than all treatments at 5% level.
[e] Significantly better than treatment 1 at 5% level.
[f] Significantly better than all treatments except 10 at 5% level.

Barnyard, crab, foxtail and spreading witch grasses were in many plots with barnyard and spreading witch grass predominant. The broad-leaved weeds that were found in many of the plots were broad-leaved plantain, common chickweed, dandelion, galinsoga, lamb's-quarters, milkweed, morning glory, narrow-leaved plantain, pokeweed, purslane, ragweed, redroot pigweed, sandbriar, smartweed, Spanish needle, three-seeded mercury, wild mustard, and wood sorrel. Ragweed and smartweed were the most common broad-leaved weeds.

Table 3. Average weed weights in tomato plots receiving various treatments

Treatment number	Treatments Applied June 7	Treatments Applied June 22	Average Weed Weights[a] Grasses (pounds)	Broad-Leaved (pounds)	Total (pounds)
1	Amiben	Simazine 80W Solan	2.10[b]	.52[bc]	2.62[bd]
2	Check		13.06	4.51	17.57
3	Eptam	Solan	3.51[b]	.20[bcd]	3.71[b]
4	Simazine 4G		7.25	3.42	10.67
5	Amiben		1.77[b]	2.05[c]	3.82[b]
6	Eptam Amiben	Solan	2.73[b]	.16[bcd]	2.90[b]
7		Solan	7.96	.55[bc]	8.51[b]
8	Amiben	Solan	1.98[b]	.32[bc]	2.30[bd]
9	Eptam Amiben		2.31[b]	1.56[c]	3.87[b]
10		Simazine 80W Solan	2.85[b]	.71[bc]	3.56[b]
11	Eptam		1.15[b]	5.77	6.92[b]
12	Hoed Check		0.0[b]	0.0[bcd]	0.0[bd]

a Weeds were taken from a 6' by 6' area inside a 9' by 12' plot to reduce likelihood of harvesting weeds from borders which may have received spray drift from adjacent plots. Weed weights are an average of the 8 replications for each treatment.

b Denotes significance over treatment 2 at 5% level.

c Denotes significance over treatment 11 at 5% level.

d Denotes significance over treatment 4 at 5% level.

All the treatments, except Simazine 4G, reduced the total weed growth over the non-hoed checks.

Plant weights were taken after all the fruit had been removed and weighed. The plants were cut off at ground level before weighing. All treatments had significantly larger plants than the non-hoed check. The Simazine 80W + Solan treatment had significantly larger plants than all other treatments except the hoed check and treatment 6--Eptam + Amiben followed by Solan.

SUMMARY

Simazine 1 lb/A + Solan 4 lbs/A applied June 22 was considered the best herbicide treatment in the trials. In the three measures of fruit production, early, marketable, and total

Table 4. Plant weights in tomato herbicide experiment.

Treatment number	Treatments Applied June 7	Applied June 22	Average weight per plant[a] (Pounds)
1	Amiben	Simazine 80W Solan	2.76[b]
2	Check		1.74
3	Eptam	Solan	3.95[b]
4	Simazine 4G		3.00[b]
5	Amiben		3.05[b]
6	Eptam Amiben	Solan	3.81[bc]
7		Solan	3.45[b]
8	Amiben	Solan	3.48[b]
9	Eptam Amiben		3.25[b]
10		Simazine 80W Solan	4.52[bd]
11	Eptam		3.15[b]
12	Hoed Check		4.43[be]

a Plants cut off at ground level and weighed August 23.
b Significantly larger than non-hoed check at 5% level.
c Significantly larger plants than 1, 2 at 5% level.
d Significantly larger than all treatments except 6, 12 at 5% level.
e Significantly larger than all treatments except 6, 8, 12 at 5% level.

yield, it had significantly more production than all of the other herbicidal treatments. However, it was not significantly better than the hoed check except in total marketable yield. In plant weights the Simazine 80W + Solan treatments had significantly larger plants than all other treatments except the hoed check and treatment 6--Eptam + Amiben followed by Solan. None of the treatments were significantly better than the Simazine + Solan treatment in weed control.

1 Schubert, Oscar E. and Hardin, N. Carl. 1960. Evaluation of several herbicides on tomato plants. Proc. 11th Annual Meeting NEWCC: 81-85.

ACKNOWLEDGEMENTS

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Evaluation of Several Pre-plant Herbicides for Petunias

Chiko Haramaki[1]

One of the largest expenses in growing outdoor annual flowering plants for either cut flowers or display purposes has been the cost of weeding. After the display plants are transplanted, the weeds soon outgrow and in many cases stunt the plants. The most common method of weed control in these beds has been hand weeding, but the use of pre-plant herbicides has been practiced to some extent. The purpose of this experiment has been to evaluate several pre-plant herbicides for effective weed control and also to determine how soon annual flowering plants could be planted after soil treatment.

Materials and Methods

The soil in the experimental area was Hagerstown silt loam. The soil was roto-tilled several times to a depth of 5 to 6 inches prior to treatment. The plots used were 100 square feet in area. All the pre-plant herbicides used were applied at three different concenrtrations plus a check, and replicated three times in a split plot design.

The herbicides used:

EPTC (Stauffer) - 6 pound/gallon concentrate was applied at the rates of 5, 10 and 20 pounds of active material per acre. The concentrate was mixed with a sufficient amount of water to make a gallon of mixture, which was sprinkled on each plot.

Vapam (Stauffer) - was applied at the rates of 1/2, 1 and 2 quarts per 100 square feet. It was mixed with water and then a gallon of the mixture was sprinkled on the plot.

Mylone (Miller) - a 25.5% formulation was used. It was applied at the rates of 1/2, 1 and 2 pounds of active ingredient per 100 square feet. This material was hand-broadcasted on the plots.

5996 (Niagara) - a 25% wettable powder was applied at the rates of 1, 2 and 4 pounds of active ingredient per acre. A gallon of each solution was sprinkled on each plot.

EP-161 (Morton) - a 20% emulsion was applied at the rates of 1/4, 1/2 and 1 quart per 100 square feet (43, 87 and 174 pounds of the active ingredient per acre). Forty-two milliliters of emulsifier was added for each quart of EP-161 used. The materials were mixed with water and one gallon of the mixture was sprinkled on each plot.

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The herbicides were applied on June 6, 1960. All of the plots were roto-tilled to a depth of 2 to 3 inches after treatment with the exception of the EP-161 treated plots. After roto-tilling, all plots were heavily watered.

Petunias were transplanted to these plots on different dates following treatment. Silver Medal, an F_1 hybrid multiflora single petunia was the variety used. These petunias were sown in the greenhouse on April 1, 1960 and transplanted to flats on April 22, 1960. Eight plants were planted in each plot on the following dates: one day, two days, four days, one week, two weeks, three weeks and four weeks after treatment. The plants were all watered at time of transplanting. Rainfall was supplemented by overhead irrigation.

Results and Discussion

The plots were checked for weed prevalence on July 12, and August 18, 1960, which were approximately 5 and 10 weeks after treatment. The performance of the various pre-plant herbicides on weed control is summarized in Table 1. The treatments showing reasonable weed control after 5 weeks were EPTC at 5, 10 and 20 pounds per acre; vapam at 2 quarts per 100 square feet, mylone at 1/2, 1 and 2 pounds per 100 square feet; and Niagara 5996 at 1, 2 and 4 pounds per acre. After 10 weeks, EPTC at 5, 10 and 20 pounds per acre and Niagara 5996 at 4 pounds per acre still produced good weed control.

On July 12, 1960, which was approximately 5 weeks after treatment, the petunia plants were examined for any detrimental effects due to the herbicide as affected by its rate of application, and also the date of planting after treatment. Table 2 summarizes the data on the effects of the various pre-plant herbicides on petunias.

The EPTC treated plots showed no detrimental effects on the growth of petunias planted on any date following treatment except for the petunias planted one and two days following treatment in the 10 and 20 pounds per acre plots. In these four treatments the damage was very slight.

The vapam treated plots showed only a very slight damage to petunias planted one day after treatment in the 1 quart per 100 square feet plots and to those planted two days after treatment in the 2 quarts per 100 square feet treatments. Moderate damage was found in petunias planted one day after treatment in the 2 quarts per 100 square feet treatments. The petunias in the other vapam-treated plots exhibited very slight or no damage at all.

In the mylone-treated plots, moderate or severe damage was exhibited in petunias planted one, two and four days after treatment in the 1/2, 1 and 2 pounds per 100 square feet treatments and also in the petunias planted one week after treatment in the 2 pounds per 100 square feet treatments. Slight damage was exhibited by petunias planted one week after treatment in the 1 pound per 100 square feet treatment. The other plots exhibited either no or negligible damage.

Table 1. Effect of pre-plant herbicides on weed prevalence. Treated June 6, 1960.

Herbicide	Active Rate	Weed Prevalence*	
		July 12, 1960	Aug. 18, 1960
EPTC	0	8.67	10.00
	5#/A	2.00	1.33
	10#/A	1.33	1.33
	20#/A	1.00	1.00
Vapam	0	8.00	9.67
	1/2 Qt/100 sq. ft.	8.33	10.00
	1 Qt/100 sq. ft.	4.33	7.67
	2 Qt/100 sq. ft.	3.33	5.67
Mylone	0	7.00	10.00
	1/2 #/100 sq. ft.	1.67	7.67
	1 #/100 sq. ft.	1.33	6.67
	2 #/100 sq. ft.	1.00	4.00
Niagara 5996	0	7.33	9.67
	1#/A	3.00	6.67
	2#/A	2.00	5.00
	4#/A	1.33	2.67
EP-161	0	6.67	9.67
	43 #/A	5.33	8.67
	87 #/A	6.67	8.67
	174 #/A	6.00	10.00

* 1 = No Weeds
10 = 100% Weed Coverage

Table 2. Effect of pre-plant herbicides and the date of planting on petunias. Checked five weeks after treatment.

Herbicide	Active Rate	Time of Transplanting After Treatment: 1 Day	2 Days	4 Days	1 week	2 weeks	3 weeks	4 weeks
EPTC	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5#/A	0.21	0.04	0.08	0.00	0.17	0.00	0.00
	10#/A	0.63	0.42	0.08	0.04	0.04	0.00	0.00
	20#/A	0.63	0.29	0.13	0.08	0.04	0.00	0.00
Vapam	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1/2 Qt/100 sq. ft.	0.00	0.00	0.00	0.04	0.00	0.00	0.00
	1 Qt/100 sq. ft.	0.38	0.00	0.00	0.00	0.00	0.00	0.00
	2 Qt/100 sq. ft.	2.79	0.79	0.21	0.08	0.00	0.00	0.00
Mylone	0	0.29	0.00	0.00	0.00	0.00	0.00	0.00
	1/2#/100 sq. ft.	4.79	3.50	3.00	0.29	0.00	0.00	0.00
	1#/100 sq. ft.	5.00	5.00	4.00	1.42	0.29	0.00	0.00
	2#/100 sq. ft.	5.00	5.00	5.00	4.33	0.25	0.21	0.00
Niagara 5996	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1#/A	0.00	0.04	0.04	0.00	0.04	0.00	0.00
	2#/A	0.21	0.21	0.17	0.17	0.00	0.17	0.00
	4#/A	0.46	0.42	0.38	0.00	0.00	0.00	0.00
EP-161	0	0.00	0.00	0.00	0.00	0.21	0.00	0.00
	43#/A	0.00	0.04	0.00	0.00	0.00	0.00	0.00
	87#/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	174#/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Plant Tolerance Scale:

0 - No injury
1 - Some chlorosis
2 - Slight necrosis or stunting
3 - Moderate necrosis or stunting
4 - Severe necrosis or stunting
5 - Dead

In the Niagara 5996 treated plots, little or no damage was observed in all petunias except those which were planted 1, 2 and 4 days after treatment in plots treated at 4 pounds per acre. Even these plants showed only a very slight amount of damage.

The petunias planted in plots treated with EP-161 showed no damage regardless of time of planting.

The plots which were treated with EPTC at 5, 10 and 20 pounds per acre and Niagara 5996 at 4 pounds per acre gave the best weed control and also the best petunia growth. The petunias which were growing in heavily weeded plots showed signs of severe stunting later in the summer.

Summary

Five pre-plant herbicides were applied at three concentrations. Petunia plants were transplanted to the treated plots one day, two days, four days, one week, two weeks, three weeks and four weeks after treatment.

It was found that petunia plants could be safely transplanted in some treated soils one day after application. In others at least one week delay was necessary.

Effective weed control with either no or negligible damage to the transplanted petunias were found in plots treated with EPTC at 5, 10 and 20 pounds per acre and with Niagara 5996 at 4 pounds per acre.

Dinitro for Weed Control in Gladiolus

Arthur Bing*

Weed control investigations on gladiolus have been in progress for several years on Long Island and the results have been reported to this conference (1, 2, 3). Diuron gives long lasting weed control and suppresses or eliminates a wide variety of weeds. However, Diuron may slightly delay blooming or reduce cut flower yield (3). Simazine also may adversely affect cut flower yield (3). Diuron and Simazine usually give good weed control on stock grown for corms without reducing corm yield. CIPC gives good temporary control of weeds other than the resistant weeds such as galinsoga, ragweed, or perennial grasses. Liquid Dinitro has proved to be an effective preemergence herbicide at rates of 4-12 pounds actual DNBP per acre. It can be used on emerged weeds but should be kept off of gladiolus foliage.

The past two seasons a series of tests were made to determine how safe the DNBP applications are to gladiolus. Also a test was carried out to evaluate the feasibility of a second application of granular DNBP to gladiolus in spiking or prespiking stage. Results in 1959 (3) showed that the application of liquid DNBP at 4,8, and 12 pounds actual DNBP in 100 gallons of water per acre did not reduce corm yield of variety Friendship in numbers or weight compared to hand weeded cultivated plots. There was a slight delay in flowering but no loss in cut flowers as measured by numbers or weight of flowers cut. The 1959 corms from each treatment were planted in the same plot areas in 1960 and received the same treatments. Flowering again was not adversely affected by the treatment.

On June 14, 1960 a half acre of gladiolus was planted as part of a virus transmission study. After the small corms were set in the furrows, the corms were covered by running a tractor cultivator over the rows. Immediately after covering, the half acre was sprayed with one gallon of DNBP (3 pounds per gallon) in 18 gallons of water. This kept the field free of weeds for about 5 weeks. After 7 weeks the field was cultivated and the rows hand weeded where necessary. Only a few weeds were present. In a few days as spikes began to emerge the rows were treated with a 2 foot wide band of 10% granular DNBP at 6 pounds DNBP per acre. Flowering was normal in early September. In late October a good crop of corms was dug. Weed control in the rows was good until the time of digging.

The suggested treatment is liquid DNBP at 6-8 pounds per acre before emergence followed by cultivation at the pre-spike stage and then an application of granular DNBP at 4-6 pounds actual per acre.

* Cornell Ornamentals Research Laboratory, Farmingdale, Long Island, New York

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PROGRESS REPORT ON WEED CONTROL IN NURSERY CROPS[1]

John R. Havis[2]

The Massachusetts nurseryman has weed problems in two general situations, the lining-out bed and the field. The weed problem in the lining-out bed is often most serious the year that the small seedlings or rooted cuttings are set, usually 6 to 9 inches apart in beds 4 to 6 feet wide. The second year the weed problem may be reduced by shading the soil by the plants themselves.

Nurserymen also are interested in control of annual weeds and grasses in the field. Quackgrass is a problem for most nurseries in the State,- more of a problem for some than for others. Where quack has become widespread in the nursery no other weed problem seems important in comparison.

This is a report of two years work on weed problems in the nursery: annual weeds in established plants in the field; quackgrass in field stock; and annual weeds in the lining-out beds. The work on each problem is reported separately.

FALL APPLICATION OF TRIAZINES FOR ANNUAL WEEDS

Trials of chemicals for control of annual weeds in the nursery have been conducted in Massachusetts for about 10 years, but not until the advent of simazine have the nurserymen become very much interested. Experimental results at Waltham had shown repeatedly that simazine at 2 lb./A applied in May following clean cultivation held annual weeds until about the first of August. Four pounds held the field weed-free for the season. This did not appear to solve the problem entirely because many nurserymen were so busy digging for sales and doing landscape jobs in the spring that when they could spare the time for the fields weeds had taken over. Usually, more time was available in late summer and fall. Interest was expressed in fall treatments that would check the growth of spring weeds until late May or June. Full season control was not necessary.

A few nurseries in Massachusetts have made trial applications of simazine in late summer or fall for control of annual weeds the following spring. Weed control has been generally good, lasting to about June 1 or even August or September. Injury to some plants has been observed, e.g. Azalea, Rhododendron, _Ilex crenata convexa_, _Pinus thunbergi_, _Euonymus radicans_, _Picea glauca_, and _Picea glauca densata_. Exact rates of application were difficult to determine from the grower applications, but most of the injury appeared to have resulted from rates of 4 lb./A or higher.

A replicated experiment was set up in the fall of 1959 on established _Rhododendron roseum elegans_ (12"-14" high) and _Euonymus radicans vegetus_ (8"-10" spread) at Waltham on fine sandy loam soil. Simazine, atrazine, and propazine were applied October 23, 1959, as sprays over weeds consisting mainly of chickweed, henbit, and annual bluegrass. Each plot contained 12 plants of each species, and treatments were replicated three times.

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Results

All treated plots were clean of annual weeds in April and remained so until about the first of June when weeds began to appear in the plots treated with propazine 2 lb. and simazine 2 lb. About the middle of June, Euonymus that received atrazine at 4 lb./A began to show injury.

Table 1 shows the weed control and plant injury observed at the end of June and early July. By this time, weeds had begun to grow in the plots treated with propazine 2 lb. and simazine 2 lb. Plots that received atrazine 2 lb. or 4 lb. and simazine 4 lb. were still relatively clean. Based on the number of plants dead or injured, Rhododendron could not tolerate atrazine at 4 lb., but other treatments were safe. Simazine at 2 lb. was the only treatment that did not injure Euonymus.

TABLE 1. WEED CONTROL AND PLANT INJURY JUNE 27, 1960 FROM APPLICATION MADE OCTOBER 23, 1960.

CHEMICAL	RATE (lb./A)	AVERAGE WEED CONTROL RATING*	RHODODENDRON (No. out of 12 plants) DEAD	INJURED	EUONYMUS INJURY (July 8, 1960)
Check	--	1	0	1	None
Propazine	2	5	0	0	Slight
Atrazine	2	8.3	1	1	Moderate
Atrazine	4	8.7	4	3	Severe
Simazine	2	4.3	1	0	None
Simazine	4	9	0	0	Slight

*Weed Control Ratings: 1 = no control; 9 = clean

This and other trials have shown that a fall application of simazine at 2 lb./A gave practical control of annual weeds until about the first of June, when crabgrass was usually the first weed to appear.

From this test, it appeared that *Euonymus radicans vegetus* was quite sensitive to the triazines. Atrazine was more injurious than simazine. The symptom of injury to Euonymus was chlorotic leaves near the ends of the branches. In severe cases the plants were stunted.

QUACKGRASS IN ESTABLISHED NURSERY STOCK

All tests were conducted at a commercial nursery on sandy loam soil.

Fall Application of Triazines

All applications were sprays of wettable powder formulations in about 50 gallons of water per acre. Simazine 5 lb./A and atrazine 5 lb./A were applied September 23, 1959 to quackgrass in established Globe Arborvitae, Hemlock, and Taxus. Quack sprouted and began to grow in April, yellowed and began dying back in May, and did not re-sprout after cultivation. Plots appeared to be clean of quack in June and for the remainder of the season. The nursery plants did not show any symptoms of injury.

Simazine 2 and 2 1/2 lb./A and atrazine 2 and 2 1/2 lb./A were applied September 23 or October 14, 1959, to quack in established Globe Arborvitae, Hemlock, Taxus, and Carolina Rhododendron. Quack sprouted in April but showed evidence of having been weakened in May. Cultivation improved control, and by June the population and vigor of quack was markedly less than untreated areas. Crabgrass grew vigorously in the treated area, but quack did not return. The nursery plants did not show injury.

Propazine at 2 1/2 lb./A was applied September 23, 1959 to quack in Globe Arborvitae. The results were about equal to, but not better than, simazine and atrazine at the same rate.

A combination of dalapon 6 lb./A with atrazine 2 lb./A applied October 14, 1959 gave no better control than the same rate of atrazine alone.

Conclusion

Fall applications of simazine or atrazine at 5 lb./A gave excellent control. Simazine, atrazine, or propazine at 2 and 2 1/2 lb./A resulted in marked reduction of quack in most of the plots. Quackgrass sprouted in early spring (following the fall application) but was obviously weakened. Spring and summer cultivation appeared to aid in destroying the remaining quackgrass. Globe Arborvitae, Hemlock, and Taxus appeared to tolerate fall application of simazine and atrazine as high as 5 lb./A. Carolina Rhododendron appeared to tolerate simazine and atrazine at 2 lb./A.

Spring Application of Dalapon and Amitrol

Crop: Pyramidal Arborvitae (Thuja occidentalis) 4'-5' high in quackgrass sod.
Date of Treatment: April 29, 1960, when quack was 4" high; repeat sprays applied May 12, 1960.
Method: Sprays were directed to quack around base of plants at 100 gal./A.
Area Treated: Two feet of row, 100 feet long. The remaining middle, about 3 feet, was cultivated with rototiller.

Treatments applied:
(1) dalapon 8 lb./A (repeated)
(2) dalapon 6 lb./A (repeated)
(3) dalapon 6 lb./A + "Plyac" sticker (repeated without sticker)
(4) dalapon 6 lb./A + simazine 2 1/2 lb./A (repeated without simazine)
(5) dalapon 6 lb./A + atrazine 2 1/2 lb./A (repeated without atrazine)
(6) dalapon 6 lb./A + Karsil 4 lb./A (repeated)
(7) dalapon 6 lb. + amitrol-T 1/2 lb./A (not repeated)
(8) amitrol-T 2 lb./A (not repeated)
(9) amitrol-T 1 lb./A (not repeated)
(10) amitrol-T 1 lb./A + "Plyac" sticker (not repeated)
(11) amitrol-T 1 lb./A + simazine 2 1/2 lb./A (not repeated)

Results

Quackgrass - Amitrol-T treatments turned the tops of quack white within two weeks. The quack had begun to recover in 4 to 6 weeks and continued to grow the remainder of the season. The various combinations with Amitrol-T made no apparent difference in performance. Dalapon treatments appeared to be giving good control when observed in June and July. Some re-growth had started, however, by the end of July, and at the end of August no treatment could be rated good control. Combination with other materials made no marked difference in performance of dalapon.

Injury - All treatments produced more injury to Arborvitae than could be tolerated by the nurseryman. Amitrol-T produced white tips of lower branches; dalapon caused brown tips.

Conclusion

Spring applications of Amitrol-T and dalapon failed to give seasonal control of quackgrass, and both produced unacceptable injury to upright Arborvitae.

WEED CONTROL IN THE LINING-OUT BED

The plants used were: *Azalea schlippenbachi*, *Kalmia latifolia*, *Rhododendron Boule de Neige*, *Juniperus horizontalis*, *Taxus media hatfieldi*. The first three were about two years from seed; the last two were rooted cuttings.

The major weed problems were:

Spring and fall weeds (September-May) chickweed, henbit, annual bluegrass
Summer weeds (June-August) purslane, lambsquarter, rough pigweed

Objectives and Procedure - 1959

The objectives in 1959 were (1) to find how long a herbicidal application to weed-free soil would delay the need for hand weeding and (2) to measure the effect of such treatment on the plants.

The plants were set one foot apart in beds five feet wide on May 26,1959. The chemicals were all granular formulations. The treatments were replicated three times. The plots to receive EPTC incorporated into the soil were treated the day before plants were set, and all of the beds were rototilled 4-5 inches deep. All "surface" treatments were applied immediately after plants were set. All plots were irrigated with about 1 1/2 inches of water after "surface" treatments were applied. Irrigation was applied as needed throughout the season. The check plots were hand weeded as needed. Each treatment was cleaned when at least two of the three replications were judged to need weeding. The soil surface was loosened at the time the plots were cleaned, and a second application of certain treatments was made. Not more than two applications of any herbicide were made during the 1959 growing season.

Results - 1959

Table 2 shows the treatments, the weeding dates, and the effects on the three ericaceous plants at the end of the first season.

The check plots needed weeding six times during the season. The use of herbicides reduced the number of weedings to two or three, except that plots receiving simazine needed only one weeding for the season.

Stand counts and height measurements were made September 25, 1959. No differences were found for Taxus and Juniperus.

The results for the ericaceous plants are shown in Table 3. Using survival counts and plant height as criteria of injury, EPTC and amiben were the most injurious chemicals. CDEC caused injury at the high rate only; no injury resulted from CIPC or simazine.

TABLE 2. HERBICIDES AND RATES AT TIME OF SETTING PLANTS IN THE LINING-OUT BED WITH DATES OF WEEDING REQUIRED

TREATMENT	DATE OF FIRST WEEDING	SECOND APPLICATION OF HERBICIDE	DATES OF WEEDING SECOND	THIRD
1 EPTC 4 lb./A (incorporated)	7/6	EPTC 5 lb./A (surface)	8/18	9/21
2 EPTC 6 lb./A "	7/6	None	8/13	9/21
3 EPTC 8 lb./A "	7/6	None	8/13	9/21
4 EPTC 5 lb./A (surface)	7/6	None	8/18	9/21
5 EPTC 10 lb./A "	7/27	None	9/21	
6 CDEC 5 lb./A "	7/1	CDEC 7 lb./A	8/18	9/21
7 CDEC 10 lb./A "	7/6	Repeated	8/18	9/21
8 Amiben 4 lb./A "	7/6	Repeated	9/21	
9 Amiben 8 lb./A "	7/6	Repeated	9/21	
11 Simazine 2 lb./A "	7/27	Repeated	--	
12 CIPC 8 lb./A "	7/1	CIPC 10 lb./A	8/13	9/21

10 Check Weeded 6/8, 6/22, 7/6, 8/5, 8/13, 9/21

TABLE 3. EFFECT OF HERBICIDES ON ERICACEOUS PLANTS AT END OF THE 1959 SEASON (SEPT. 25). TAXUS AND JUNIPERUS NOT AFFECTED.

	CHEMICAL	RATE (lb./A)	METHOD	NUMBER OF APPLICATIONS	KALMIA		AZALEA		RHODODENDRON	
					SURVIVAL No./8	HEIGHT (In.)	SURVIVAL No./8	HEIGHT (In.)	SURVIVAL No./8	HEIGHT (In.)
1	EPTC	4	Incorporated	2[1]	7.7	5.4	7.7	2.9	7.3	4.3
2	EPTC	6	Incorporated	1	8.0	5.9	8.0	3.3	7.7	4.1*
3	EPTC	8	Incorporated	1	8.0	6.5	7.7	3.0	7.7	4.6
4	EPTC	5	Surface	2	7.7	4.9	7.7	2.8	6.2	3.3**
5	EPTC	10	Surface	1	7.3	4.2**	4.0**	2.6	4.0**	3.0**
6	CDEC	5 & 7	Surface	2	8.0	6.4	8.0	3.5	8.0	4.8
7	CDEC	10	Surface	2	8.0	7.0	7.3	3.1	8.0	3.8**
8	Amiben	4	Surface	2	8.0	5.5	5.0**	2.7	8.0	4.4
9	Amiben	8	Surface	2	8.0	5.0	2.7**	2.3	6.2	4.2*
11	Simazine	2	Surface	2	8.0	5.8	8.0	3.1	8.0	5.0
12	CIPC	8 & 10	Surface	2	8.0	7.5	7.7	3.4	7.7	4.7
10	CHECK	--	--	-	8.0	6.1	7.7	3.5	7.7	5.3

[1]Second application 5 lb./A to surface 7/5/59

*Significantly different fromcheck at 5% level

**Significantly different from check at 1% level

Fall Applications

The plots used in the 1959 season were treated October 22, 1959, for control of late fall and early spring weeds. Most of the fall chemicals were the same as used the previous season. Important changes were the substitution of atrazine 1 and 2 lb./A and simazine 1 lb./A on plots that originally received EPTC incorporated before planting. The plots were mulched lightly for the winter with salt marsh hay.

Table 4 shows the fall treatments and the weed control ratings made six weeks after the mulch was removed in the spring of 1960.

TABLE 4. TREATMENTS OF GRANULAR HERBICIDES OCTOBER, 1959 AND WEED CONTROL RATINGS MAY 16, 1960

PLOT NO.	HERBICIDE	RATE (lb./A)	WEED CONTROL RATING*
4	EPTC	3	3.7
6	CDEC	4	6.3
7	CDEC	8	7.3
12	CIPC	4	4.0
1	Atrazine	1	7.0
2	Atrazine	2	9.0
3	Simazine	1	7.0
11	Simazine	2	9.0
10	Check	--	1.3

*Weed Control Rating: 1 = No control; 9 = clean

Plots with 2 lb./A of either simazine or atrazine were clean. Satisfactory control was obtained with 1 lb./A of either simazine or atrazine and with 8 lb./A of CDEC. There was some plant loss over winter but loss was not associated with treatments. Replacements were made on May 16, 1960, to give each plot its full complement of plants.

Objectives and Procedures, 1960

Most of the herbicides used in the 1959 season gave weed control for four to five weeks. The application plan for the 1960 season was to treat each month. It was thought that this would give a new supply of herbicides at about the time of depletion, and require a minimum of labor for weeding. Existing weeds were merely pulled out. The soil surface was not loosened before application of herbicides. The EPTC plots were given 1/2 inch of water after each application.

Two treatments, simazine 2 lb./A and atrazine 2 lb./A, were applied only when weed ratings dropped below 7.0 ("commercial" control). The October, 1959 application of these two treatments kept the plots "commercially" clean until the end of June, even though the soil was disturbed in making plant replacements in May.

Results

Table 5 shows the herbicides used and the weed control ratings each month prior to cleaning the plots of existing weeds.

TABLE 5. HERBICIDES APPLIED MONTHLY DURING THE 1960 SEASON AND WEED RATINGS JUST PRIOR TO EACH APPLICATION

The first application was made May 16.
Plot Numbers correspond to same plots as in Tables 2, 3, and 4.

PLOT NO.	HERBICIDE[1]	RATE (lb./A)	WEED CONTROL RATINGS[2] JUNE 16	JULY 15	AUG. 12	NOV. 3	AVERAGE
4	EPTC	4	5.7	5.3	6.3	5.7	5.8
6	CDEC (spray)	8	7.3	3.0	6.7	5.7	5.7
7	CDEC	8	7.7	6.0	7.3	7.0	7.0
12	CIPC	8	5.0	5.3	6.0	4.7	5.2
1	Atrazine	1	9.0	8.3	8.7	9.0	8.8
3	Simazine	1	8.0	6.7	8.0	8.3	7.8
	(Treatments below were applied July 1 and August 12 only)						
2	Atrazine	2	7.0	8.7	7.0	9.0	7.9
11	Simazine	2	7.7	7.7	6.7	9.0	7.8

[1]All herbicides were applied as granular except as indicated.

[2]Weed Control Ratings: 1 = no control; 9 = clean
A rating of 7 meant that only a very few small weeds were present and plots could be cleaned quickly.

Of the treatments applied monthly, the best weed control resulted from simazine 1 lb./A and atrazine 1 lb./A. Second best, but satisfactory weed control, was CDEC 8 lb./A granular. Consistently poorer ratings resulted from CDEC 8 lb./A as spray, EPTC 4 lb./A, and CIPC 8 lb./A.

The plots receiving atrazine 2 lb./A and simazine 2 lb./A "when needed" required two weedings and two applications for the season. Check plots were weeded five times.

Stand counts and height measurements of the plants were taken November 8, 1960 to evaluate the injury from herbicidal treatments. The results showed that (1) Taxus and Juniperus apparently were not affected by the treatments, (2) stand of ericaceous plants was not affected by the treatments, (3) height measurements gave significant differences for Azaleas only. The measurements showed inhibited growth of Azaleas from two years applications of EPTC (5 lb. first year and 4 lb. second year); CDEC (10 lb. first year and 8 lb. second year); Simazine (2 lb. both years).

Conclusions

An experiment carried two years gave certain indications of the influence of granular herbicides in the lining-out bed on five species of woody ornamentals. Of the five species, Taxus and Juniperus appeared to tolerate all chemicals at all rates used. Considering herbicides used two full seasons from the time of setting: Kalmia appeared to tolerate CIPC, CDEC, and Simazine; Rhododendron appeared to tolerate CIPC and Simazine; Azalea tolerated CIPC only.

Granular simazine and atrazine at 1 and 2 pounds per acre gave effective weed control, and liner size plants of several species apparently could tolerate those rates. The use of 1 or 1 1/2 pounds per acre of these herbicides would seem to be especially worthy of further trials.

Because of its apparent safety to a wide range of plants, CIPC would appear to be a useful herbicide for plants that are sensitive to the triazines.

GENERAL REMARKS

The work reported here included herbicide trials in the lining-out bed and in field-grown nursery stock. Simazine and atrazine were promising for both bed and field. Wettable powder and granular forms were used.

Simazine and atrazine gave similar results in all tests reported except one. In this one test, which involved fall applications for control of annual weeds in Rhododendron and Euonymus, atrazine gave longer lasting control but also more injury to the ornamentals. Simazine is probably the safer material for certain plants.

Impressive control of annual weeds was obtained with as little as 1 pound per acre. If we do not demand that one application give full season control, low rates of application can be useful on small liners and on species that are injured by the high rates.

Fall application of the triazines showed promise of being very helpful in the control of quackgrass. The minimum rate of application necessary for practical control was not determined, but it would appear to be between 2 and 5 pounds per acre. Timely cultivation the following season may be important in obtaining control of quackgrass with reasonable rates.

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Effects of Granular Herbicides on Newly Planted Nursery Liners[1]

John F. Ahrens[2]

Abstract

In nursery plantings, the greatest weed problems often occur during the first year or two after plants are lined out in the field. Several pre-emergence herbicides have appeared promising for use in plantings of this type. Information is lacking, however, on the effects of repeated applications of these herbicides, both on the existing and future nursery plantings. Information also is needed on factors affecting the response of nursery liners to granular applications of herbicides. To obtain such information, experiments were conducted with liners of yew (Taxus spp.) and hemlock (Tsuga canadensis), as test plants. The herbicides included simazine, neburon, CIPC, EPTC, CDEC, NPA, 2,4-DEP, DNBP and sesone.

Permanent plots were established for each herbicide and dosage level. In one experiment annual plantings and herbicide applications were made over a 3-year period. In another test a single herbicide application a week after planting was followed by two applications during the second year. Oat cover crops and oat bioassays of soil samples taken from plots were used to indicate the presence of herbicide residues.

In a third experiment, we investigated the effects of plant age and time of treatment after transplanting upon the susceptibility of hemlocks to granular simazine and CIPC.

With the exception of Taxus cuspidata capitata, yews were very tolerant of the granular pre-emergence herbicides tested. Hemlock liners were more susceptible to injury than yews. At normal herbicide dosages, however, growth of yews and hemlocks improved, probably because of weed control. Repeat treatments with certain herbicides, applied either annually or twice in a season, injured liners only at high dosages.

The tolerance of hemlocks to granular applications of simazine and CIPC was increased greatly by delaying treatment for a longer period after transplanting. Tolerance to these herbicides also increased with age of the transplants. There is evidence to indicate that tolerances of other nursery plants may be influenced by factors of age and degree of establishment.

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[1]Contribution of the Connecticut Agricultural Experiment Station, Windsor, Conn., to be submitted for publication in the journal of The Weed Society of America.

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Residual herbicide activity was most pronounced with simazine. Dosages above 3 lbs./A. provided seasonal control of weeds. Even with simazine, however, there was considerable loss of activity in a sandy loam soil. One year after a second annual application of simazine at 3 lbs./A., less than 0.25 lbs./A. was detected in the upper 4" of soil and none was detected at depths of 4-8". With EPTC most of the phytotoxic residue was found at depths below 4". The residues were somewhat less than those required to injure most woody plants. This and other evidence suggests that normal dosages of these herbicides, applied as needed, will not result in the accumulation of residues toxic to future plantings of species with tolerances similar to those treated.

WEED CONTROL EXPERIMENTS WITH NURSERY PLANTS

Arthur Bing*

This report is on a continuation of the weed control experiments being carried out at the Cornell Ornamentals Research Laboratory on Long Island and in commercial nurseries in the New York metropolitan area. This work is being carried out in collaboration with Dr. Pridham at Ithaca. There are several separate experiments being carried on and each will be discussed separately.

Tolerance of Nursery Stock to Herbicides

There is much interest in which herbicides at what strength can be used on woody ornamentals growing in the nursery row or in a landscape planting. This experiment is concerned with the planting of a variety of young woody plants and treating them with various rates of herbicides. One set of Atrazine plots was raked in after treatment to see if it improved or lowered the usefulness of the material. A similar trial was carried out with EPTC.

Four hundred foot rows containing 200 liners 2 feet apart were planted with 3 feet between rows. There were two rows of Taxus cuspidata Hicksii (Hicks yew), and one each of Ilex crenata convexa (Boxleafed Holly) , Juniperus hetzii (Hetz juniper), Ligustrum ovalifolium (California privet), Rhododendron obtussum var. Hinocrimson (Hinocrimson azalea), and Hydrangea macrophylla var. Stratford (Stratford hydrangea). Plantings were made on May 3 to 11, all rows were tractor cultivated on May 12, and herbicidal treatments made on May 13 and 17. Each treatment consisted of 1 concentration of a material across the rows to include 2 plants in each row.

The granular treatments were applied with a calibrated lawn spreader mounted on large wooden wheels. The liquids were applied with a 1 1/2 gallon hand sprayer equipped with a flat spray nozzle. Liquid was applied at 1 quart per 100 square feet which is equivalent to 100 gallons per acre. The treatments and rates used are shown in Table 1. One set of Atrazine treatments was raked in (cult) the other was left undisturbed. EPTC treatments were also applied in duplicate and one set of treatments raked into the soil. Atrazine plus Zytron and Atrazine plus Dacthal were used to try to control crabgrass which usually comes up strong in otherwise clean Atrazine plots.

The Dacthal, Zytron, CDEC, Amiben, and CIPC plots became weedy fairly early and were hand weeded. Weed ratings were made June 18 before the hand weeding and on August 17-24 when all plots were cultivated and hand hoed. Cultivation was continued weekly until fall treatments were made in early November 1960. Plant tolerance data were taken September 16. Table 2 shows the minimum rate of any herbicide used in the experiment that caused marked injury during the four month growing period. Atrazine did not seriously affect Ilex at any of the rates used (see Table 1 for rates used) but at 8 pounds per acre was harmful to privet. Simazine and Atrazine were quite

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Table 1. Herbicides and Rates Used on Nursery Stock

Applied 5/13-5/17/60

Material	Formulation	Rates Used Pounds Actual Per Acre
Untreated	Hand hoed	
Simazine	4% granular on clay	2,4,6,8,10
Simazine	80% W.P.	2,4,6,8,10
Atrazine	4% granular on clay	2,4,6,8,10
Atrazine plus	4% granular on clay	2, 4, 6, 8
Zytron	25% granular on vermiculite	25, 20, 15, 10
Zytron	25% granular on vermiculite	10,15,20,25,30
Atrazine plus	4% granular on clay	2, 4, 6, 8
Dacthal	5% granular on clay	8, 6, 4, 2
Dacthal	5% granular on clay	4,6,8,10,12
DNBP	10% granular on clay	4,6,8,10,12
CDEC	20% granular on clay	4,6,8,10
CIPC	5% granular on clay	4,8,12,16,20
Diuron	2% granular on clay	1,2,3,4,6
EPTC	6% granular on clay	3,6,9,12,15
Amizine containing	Wettable Powder	
Amino triazole	15%	
Simazine	45%	4,6,8,10
Amiben	10% granular on clay	3,6,9,12
Black Plastic	2 mil sheets	1 thickness

Table 2. Tolerance of Some Nursery Plants to Herbicides. Figures show minimum rates of pounds actual to cause marked injury. See Table 1 for rates used. (Treated 5/13-17/60 Observed 9/16/60)

	Pounds per acre actual required to cause injury to					
Treatment	Hicks Yew	Boxleafed Holly	Hetz Juniper	Calif. Privet	Hinocrimson Azalea	Stratford Hydrangea
Untreated	-	-	-	-	-	-
Simazine 4% G	-*	-	-	8	6	2
Simazine 80% W.P.	-	-	-	8	2	2
Atrazine 4% G	-	-	-	4	2	2
Atrazine 4% G cult	-	-	-	8	4	2
Atrazine 4% G plus						
Zytron 25% G	-	8	8	4	2	2
Zytron 25% G	-	-	-	-	-	-
Atrazine 4% G plus						
Dacthal 5% G	-	-	-	4	4	2
Dacthal 5% G	-	-	-	-	-	-
DNBP 10% G	-	-	-	-	-	-
CDEC 20% G	-	-	-	-	-	-
CIPC 5% G	-	-	-	-	-	-
Diuron 2% G	6	3	-	-	-	1
EPTC 6% G	-	-	-	-	-	-
EPTC 6% G cult	-	-	-	-	12	-
Amizine	-	-	-	-	-	4
Amiben 10% G	-	-	-	-	-	-
Black Plastic	-	-	-	-	-	-

* - No injury at rates used.

Table 3. Weed Control on Nursery Stock

Treatment	Rate required for commercial weed control	Weeds still a problem at commercial levels							
		Mustard	Rag-weed	Galin-soga	Lambs quarter	Red root	Knot weed	Crab-grass	Nut grass
Untreated									
Simazine 4% G	6	z	z			z			z
Simazine 80% W.P.	4		z						
Atrazine 4% G	2							z	
Atrazine 4% G cult	2	z	z					z	
Atrazine 4% G Zytron 25% G	Same as for Atrazine 4% G								
Zytron 25% G	*	z	z		z				
Atrazine 4% G Dacthal 5% G	Same as for Atrazine 4% G								
Dacthal 5% G	*	z	z	z		z	z		
Dinitro 10% G	4					z		z	
CDEC 20% G	*	z	z		z	z	z	z	
CIPC 5% G	12		z						
Diuron 2% G	2								z
EPTC 6% G	12	z							
EPTC 6% cult	6			z					
Amazine 15% ATA 45% Simazine	6								
Amoben	12			z					
Black Plastic									z

* Not sufficient control at rates used

harmful to privet and azaleas at moderate rates and hydranges was actually killed at 2 pounds per acre - the lowest rate used. Zytron, Dacthal, CIPC, DNBP and CDEC, and Amiben were not harmful at any of the rates used. Atrazine and Diuron at the higher rates caused yellowing of the leaves of Ilex.

Table 3 lists chemicals and minimum rate of application necessary for commercially adequate weed control and indicates which weeds tend to be a problem at that otherwise useful rate. Simazine granular at 6 pounds per acre gave fairly good weed control but a few mustard, ragweed, knotweed, and nutgrass survived. Atrazine that was not raked into the soil gave better weed control that that raked into the soil. Crabgrass was the only problem on plots treated with Atrazine at 2 pounds per acre. The raked-in plots had some mustard and ragweed surviving. Galinsoga was a problem in Dacthal, EPTC, and Amiben plots. Weed growth was not evenly distributed in all the plots. Hence, some weeds might have been a problem in some treatments even though they did not appear as such in the experiment because they were not plentiful in that area.

Residual Effect

In another area granular herbicidal treatments have been repeated on the same soil for 6 years for Diuron and CIPC and 3 years for Simazine. The rates used are Diuron 1 1/2 pounds, CIPC 8 pounds and Simazine 6 pounds actual per acre. Plants now in the plots are Berberis verruculosa, Ilex crenata var. Helleri, Pieris japonica, Rhododendron molle, Rhododendron obtussum var. Hinodegeri, Ilex crenata convexa, Taxus cuspidata, Rhododendron catawbiense, Leucothoe caetsbei, Syringa vulgaris grafted on privet, Enkianthus campanulatus, Pieris floribunda, Ilex opaca, Juniperus hetzii, Berberis julianae, Hedera helix, and Osmanthus ilicifolius. Continued use of Diuron on the soil was reducing growth or injurying Pieris japonica second year plants and Rhododendron obtussum second year plants. CIPC was injuring Pieris japonica second year plants. Simazine was injurying Rhododendron molle second year, Rhododendron obtussum second year plants, Syringa vulgaris third year plants and Enkianthus first year plants. One Ilex crenata in the Simazine plot had extensive yellowing of foliage. All the other kinds of plants were doing well in the three treatments.

In plots where CIPC was used at 12 and 16 pounds per acre for 5 years and Diuron at 3 and 4 pounds for 5 years, Taxus cuspidata Hicksii was doing well after two seasons.

Dinitro for Chickweed Control

Several years ago dormant Taxus varieties and Ilex crenata convexa were sprayed with DNBP at 3-4 1/2 pounds per 100 gallons of water to control chickweed that was growing over the plants. The results were successful and commercial growers have since used this treatment. On October 7, 1960 yound chickweed was developing in established nursery stock. The rows were treated with 4-6 pounds of DNBP by applying 10% granular with a Cyclone rotary spreader. By October 11, the chickweed was eliminated and was not regrowing one month later.

Treating Established Hemlock

A nurseryman asked about controlling weeds, especially quackgrass, in an established planting of large hemlocks. On a clear hot April 15, 1960 parts of rows of hemlocks were treated with Atrazine 4% granular at 2,4,6,8,10, Simazine 4% granular at 2,4,5,8, and 10, and CIPC 5% granular at 4,8, and 16 pounds actual per acre. Several observations were made of this planting during the growing season. There was no plant injury from any of the treatments.

Final observations were made on November 18, 1960. Atrazine at 4 pounds or more per acre and Simazine at 6 pounds or more per acre gave more than satisfactory commercial weed control. At higher rates of Atrazine and Simazine quackgrass was entirly eliminated. CIPC was not effective against quackgrass. Simazine 80% W.P. at 10 pounds per 100 gallons sprayed on a hemlock April 15 did not injure the plant.

Conclusion

This work is being continued trying to apply experimental data to nursery usage as soon as possible.

[1] Many of the plants and some assistance in planting came from the State University Agricultural and Technical Institute at Farmingdale. Other plants came from Otto Muller Greenhouses East Meadow, New York, and Hicks Nursery, Westbury, N. Y.

THE USE OF SEVERAL HERBICIDES ON PERENNIALS

Arthur Bing*

The use and appreciation of biennial and perennial ornamental plants is limited by the cost of controlling weeds. The growth habits of most of these plants and the long period they remain in one location make close clean cultivation very difficult if not impossible. Ornamental plants occur in a wide variety of families and genera and frequently are close relative to weeds that the woody plant nurseryman is trying to control. Herbicides with a long lasting effect that will kill most weeds and still not adversely affect a particular crop are desirable.

Certain perennial weeds have shown specific resistance to certain herbicides. For this reason an experiment was conducted with some of the more promising long lasting herbicides on some of the more important perennials and biennials. Daffodil, Dahlia, Day lily, Oriental Poppy, Pansy, Peony, Phlox, and Tulip were included in this study.

Daffodil (Narcissus pseudo narcissus)

A grower was interested in weed control on field grown daffodils. The bulbs are planted in rows in the field for 2 years after forcing in the greenhouse for winter cut flowers. After growing in the field they are again planted in flats and forced in the greenhouse.

On May 2, 1960 after the daffodils had flowered in the field the treatments shown in Table 1 were made on 20 foot sections of row.

Table 1. Herbicides Used on Daffodils (Friar's Head Farms 1960)

Material	Rates Used In Pounds Actual Per Acre
Simazine 4% G	2,4,6,8,10
Atrazine 4% G	2,4,6
DNBP 10% G	4,6,8
CIPC 5% G	8,12
EPTC 6% not cultivated	3,6
Diuron 80% W.P.	1

Observations made in June, showed no crop injury from any of the treatments. Weed control was good for treatments of Simazine, Atrazine, Diuron and higher rates of DNBP. Grass was beginning to grow in the lower DNBP treated areas. EPTC was not effective probably because of the hard uncultivated soil at the time of application. Further observations on

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flowering and growth in the spring of 1961 will be necessary to properly evaluate crop tolerance.

Dahlia (Dahlia pinnata)

Treatments on newly planted dahlias with Simazine, CIPC, and Diuron in 1959 showed good crop tolerance and good weed control. This limited test was repeated in 1960 with similar results. A large scale series of treatments was made on June 10 on a dahlia planting at the U. S. Veterans Hospital, Northport, L.I.,N.Y. The rows were 200 feet long and 4 feet apart. Plants had not yet emerged from the soil and the area was fairly free of weeds. Replicate treatments were made on half rows with liquid Simazine 80% W.P. at 1, 2, 3, and 4 pounds actual per 100 gallons of water per acre and Diuron 80% W. P. at 1, 1 1/2 and 2 pounds actual per 100 gallons of water per acre.

None of the treatments injured the dahlias. Weed control was evaluated on July 25. Simazine at 1 and 2 pound rates gave good weed control except for a few crabgrass, barnyard grass, and purslane. Simazine at 4 pounds controlled all weeds except a few grasses. Diuron at 1 pound gave fairly good initial control but by July 25 a few small grasses, purslane, and red root were coming in. Diuron at 1 1/2 pounds gave better control but similar weeds to those in the 1 pound plots were coming up. At the 2 pound rate of Diuron only a few purslane were emerging.

Daylily (Hemerocallis sp.)

Daylilies are very desirable perennials that are left in the same location for many years. In the fall of 1959 and the spring of 1960, herbicidal treatments with Simazine 4% G at 4,6,8, and 10, EPTC 6% G at 3 and 6, and Amiben 10% G at 4 and 8 pounds actual per acre were applied to established daylilies. During the 1960 growing season there were no signs of injury from any of the treatments. Fall applications of Simazine resulted in the best weed control. Larger scale treatments with Simazine at 4-6 pounds per acre were made during early November 1960.

German Iris (Iris sp.)

Treatments made on iris several years ago showed CIPC to be fairly safe on iris and to give fair weed control. Quackgrass is the most troublesome weed in iris plantings and it is not controlled by CIPC. Simazine controls quackgrass in peonies. In the fall of 1959 iris plants at the Martin Viette Nursery were treated with Simazine 4% G at 4,6,8, and 10 pounds actual per acre, EPTC 6% G at 3 and 6 pounds actual per acre, and with Amiben 10% G at 4 and 8 pounds actual per acre. The treatments were repeated on adjacent rows in the early spring of 1960.

None of the herbicidal treatments produced any signs of injury during the growing season. Simazine applied during the fall gave the best weed control. Six pounds of Simazine per acre gave good weed control.

A large area of iris was treated with Simazine in November 1960 to substantiate the previous seasons results.

Oriental Poppy (Papaver orientale)

An established planting of Oriental poppies at the Martin Viette Nursery was treated in the fall of 1959 and adjacent rows in the spring of 1960 with Simazine granular at 4,6,8, and 10 pounds, EPTC at 3 and 6 pounds, and Amiben at 4 and 8 pounds actual per acre. Simazine controlled weeds best but yellowed the leaves at all rates. Some burning of leaves occurred at the 6 and 8 pound rate and dwarfing of plant occurred at the 10 pound rate. The grower did not consider the yellowing from Simazine serious and fertilizer application might do away with the yellowing. The poppies were not adversely affected by EPTC or Amiben. The grower is interested in again trying the lower Simazine rates in the fall of 1960 because of the better weed control.

Pansy (Viola tricolor)

Pansy seed is usually planted in August and the transplants set out in beds in September or early October. However, later planting produces smaller, easier to handle plants which do not flower until spring. This is desirable. Seed beds and transplant beds are being effectively treated for weed control by preplant treatments with steam, methyl bromide, or Vapam. Growers are interested in a less expensive post-plant treatment.

On October 18, 1959 mixed pansies were planted 6 x 6 inches in 2 beds 3 feet wide and 20 feet long. On October 21, granular treatments were made on groups of 24 plants by treating a 2 foot wide strip across the 3 foot bed. The pansies were covered with salt hay in December and uncovered in mid March. Plant stand and weed control were observed on May 6, at which time the plants were just past the stage at which they could be sold.

Table 2 lists the treatments made on October 21 with the survival of pansy plants rated as good, fair or poor, and the weed control rated as being poor "1" to excellent "10". Henbit was the predominant weed. Amiben gave good weed control but killed the pansies. Neburon gave fairly good weed control and the pansies made good growth. EPTC at 3-5 pounds per acre gave good weed control and plant stand was good. CIPC gave only fair weed control and fair crop tolerance. Simazine and Atrazine gave good weed control but pansies were completely eliminated by Atrazine and by Simazine at rates over 1 pound per acre. The mixture of 6% CIPC with 4% Sesone was not effective giving poor crop stand and only fair weed control.

EPTC and Neburon showed promise for post planting weed control on pansies and more extensive trials are being made in 1960-61.

Table 2. Pansy Weed Control (Planted 9/18/59)

Treatment 9/21/59 pounds actual/acre	Weed Control* 5/6/60	Plant Stand 5/6/60 Out of 24 plants		
		Good	Fair	Poor
Untreated	1	19	3	0
Amiben 10% G 1	8	6	7	8
2	10	0	0	7
4	10	0	0	7
6	10	0	0	9
8	10	0	0	3
10	10	0	0	1
Untreated	1	15	7	1
Neburon 4% G 4	4	18	2	2
6	8	21	0	2
8	8	19	1	1
10	3	17	2	1
Untreated	1	23	1	0
EPTC 6% G 2 cult	8	19	3	0
3 cult	10	16	1	3
4 cult	10	18	1	2
5 cult	9	17	1	1
6 cult	10	11	7	1
6 Uncult	9	18	4	0
Untreated	1	24	0	0
Chloro IPC 5% G 6	3	18	3	2
8	8	15	4	1
12	7	11	5	5
16	9	12	9	3
Untreated	3	18	2	1
Simazine 4% G 1	9	9	6	0
2	10	0	0	0
3	10	0	0	0
Atrazine 4% G 1	10***	0	0	0
2	10***	0	0	0
3	10***	0	0	0
Untreated	1	12**	0	0
Untreated	1	23	1	0
Untreated	1	23	1	0
Chloro IPC 3 + SES 2	6	10	5	0
Chloro IPC 6 + SES 4	6	10	5	3
Chloro IPC 9 + SES 6	8	4	2	1
Chloro IPC 12 + SES 8	7	0	1	1
Untreated	3	23	1	0
Untreated	3	23	0	0

* Weed control 1 - no control 10 - no weeds

** Two rows on the side toward atrazine were killed by the atrazine.

*** Crabgrass coming in heavy in spite of good control of other weeds.

Peony (Paeonia albiflora)

The use of Simazine at 5-10 pounds actual per acre and Diuron at 2-4 pounds per acre was continued for the third year on the same plots. Both granular and liquid applications were made on January 25, 1960. Amiben 10% granular was used for the first time in 1960 at rates of 4-10 pounds actual per acre. With the mixed varieties used there was no crop injury from even the highest rates used.

The Simazine treatments gave slightly better weed control than the Diuron. The small veronica that was rather prevalent in Diuron plots last year came in still heavier this past season. The Amiben failed to control the already started grasses. One half of a row that had been an outside untreated row for the past two seasons was treated with liquid Simazine at 5 pounds actual per acre on January 25. In spite of the established weeds especially already emerged grass at treatment time the newly treated half-row was weed free by late spring.

Simazine was used commercially on several large fields of peonies. Treatments were made using granular Simazine at 4-6 pounds per acre or liquid at 3-4 pounds per acre on clean ground. In general, good peony growth and weed free ground was the result. At lower rates of Simazine barnyard grass (Echinochoa crusgali)can be a problem. Where applications were made by growers to very weedy fields at rates of 6-8 pounds per acre, weed control was more spotty. However, there was fairly good quackgrass control at the higher rates. Uneven applications by growers of granular gave spotty control and caused injury to some varieties. Varietal susceptibility may be quite variable although most varieties treated were unaffected by treatments. If only a few varieties are sensitive the grower would eliminate these or grow them in untreated areas. The results with herbicides are so encouraging that peony growers are adopting the use of Simazine or Diuron as a standard cultural practice.

Summer Perennial Phlox (Phlox paniculata)

Earlier experiments and grower field trials showed Phlox paniculata to be very sensitive to CIPC. In the fall of 1959 and spring of 1960 treatments were made to Phlox growing in the Martin Viette nursery using Simazine granular at 4,6,8, and 10 pounds and EPTC 6% granular at 3 and 6 pounds per acre. Simazine at all rates used was very harmful to Phlox. All but the lowest rate eventually killed Phlox. EPTC caused a contortion of the leaves especially from the spring application. This contortion has also been observed on greenhouse snapdragons planted in soil treated with EPTC.

Phlox is quite sensitive to the herbicides so far tested.

Tulip (Tulipa gesneriana)

A planting of mixed tulips was made in November 1959. They were treated across the rows with the treatments listed in Table 3 on January 25, 1960. After treatment all rows were covered lightly with salt hay.

Table 3. Herbicides Used on Tulips

Material	Rate Used in Pounds Actual Per Acre
Simazine 4% G	1,2,3,4,6,8,
Diuron 2% G	1,2,3,4,
CIPC 5% G	4,6,8,12
Amiben 10% G	2,4,6,8,10
Neburon 4% G	4,6,8

When the plants came up in April the salt hay was removed. All plots flowered well. Weed control was most long lasting in the Diuron plots, which were still free of weeds in November 1960. The Simazine plots were fairly clean until late summer when grasses appeared. The plots will remain for evaluation of flowering in the spring of 1961.

Summary

The fall treatments of daylilies, iris and peonies with granular Simazine looks very promising. Post plant treatments of pansy transplants with EPTC or Neburon also look good. Larger scale trials of these promising treatments are being carried out in the growers' fields.

EVALUATION OF SEVERAL HERBICIDES ON STRAWBERRY PLANTS DURING THEIR FIRST GROWING SEASON.

Oscar E. Schubert and Peter C. Rogers[1]

Weeding strawberry plants in a matted-row system of culture becomes increasingly more difficult and time consuming as more and more runner plants are formed during the season. The purpose of this experiment was to determine if herbicides alone could be used for adequate weed control without any additional hand weeding and without excessive injury to the strawberry plants. With Sesone it is necessary to remove all weeds before the next application is made because weeds that have already emerged are seldom killed unless extremely small.

MATERIALS AND METHODS

In early April, 1960, Catskill strawberry plants were set about 18 inches apart in rows 4 feet apart on a medium sandy loam at Schubert Gardens, Morgantown, West Virginia. The planting was weeded with a rotary cultivator and hand-hoed until June 19. Since at this time runners were forming and elongating rapidly, this was the last time it would be practical to cultivate without considerable slow hand weeding.

The herbicide treatments and application dates are given in Table 1. Each plot was 9 feet wide and 12 feet long and had an average of 12 to 15 plants. The herbicide treatments were assigned at random within each of the four replications. Plots with similar plant numbers and vigor of plants were grouped into separate replications.

RESULTS AND DISCUSSION

Weeds were present in the herbicide plots one month after the first herbicide application. Since the main purpose of this experiment was to ascertain whether herbicides could safely control weeds without additional hand weeding, a second application was now necessary. Purslane was coming into the Eptam plots and a mixture of grasses and weeds were found in varying proportions in all the other plots. Weed control was very good in the Casoron plots on July 21 but injury to the strawberry plants was excessive so a second treatment was not applied. The Dacthal plus Simazine plots were not sprayed again, although some plots were becoming weedy, because it was hoped the weeds would be killed if given additional time. By the time this error was evident it was too late to control the grasses in the plots with Karsil although adequate control of the broad-leaved weeds would have been possible.

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Table 1. Herbicide treatments applied to Catskill strawberry plants.

Treatment number	Herbicides applied June 20-21, 1960. Herbicide and Formulation	Rate[b] a.i. lb/A	Type of Application	Herbicides applied as a spray on July 21, 1960. Herbicide and Formulation	Rate[b] a.i. lb/A
1	None	(non-hoed check)			
2	Eptam-5G[b]	6.0	Raked into soil 1 1/2"	Karsil-2EC + Simazine-80W	4.0 1.5
3	Casoron-4G	4.0	Surface[c]		
4	Karsil-2EC + Simazine-80W	4.0 1.5	Spray Spray	Karsil-2EC	4.0
5	Karsil-2EC	4.0	Spray	Karsil-2EC + Simazine-80W	4.0 1.5
6	Simazine-80W	1.5	Spray	Karsil-2EC	4.0
7	Dinoben-10G	4.0	Surface	Karsil-2EC + Simazine-80W	4.0 1.5
8	None	(Hoed check--hoed as needed for weed control)			
9	Dacthal-1.5G + Simazine-8CW	8.0 1.5	Surface Spray		

a G = granular, EC = emulsifiable concentrate, W = wettable powder.
b Rate expressed as active ingredient in pounds per acre.
c Granular herbicide broadcast on surface as evenly as possible with a salt shaker.

The July 21 treatments were either a spray of Karsil by itself if Simazine had been used in the June 21 treatment, or a combination of Karsil plus Simazine if Simazine had not been used earlier. Karsil was the only herbicide available to us that would kill annual grasses 1-1 1/2" tall and also kill larger broad-leaved weeds without appreciable injury to strawberry plants. Karsil, however, could be expected to give only temporary control of grasses so it was necessary to add Simazine for longer residual weed control, if Simazine had not been used in the June 21 treatments. All previously treated plots, except the Casoron and the Dacthal plus Simazine plots received an application of either Karsil or Karsil plus Simazine on July 21.

Between August 30, and September 8, 1960 all grasses and broad-leaved weeds were pulled and weighed separately for each plot. The average weight of grasses and broad-leaved weeds for each treatment is given in Table 2. In the following discussion on weeds the hoed-check plots will not be included since weeds were removed periodically throughout the season. These hoed-check plots are of value for comparing plant stand and yield in 1961.

Table 2. Average weight of broad-leaved and grassy weeds in strawberry herbicide plots.

Treatment number	Herbicide used on: June 20-21, 1960	Herbicide used on: July 21, 1960	Average weight of weeds in four replications,-Aug. 30 - Sept. 8: Broad-leaved (lbs.)	Grasses (lbs.)	Total (lbs.)
1	None-(Non-hoed check)		54.35	58.50	112.85
2	Eptam	Karsil + Simazine	0.15[a]	1.30[ab]	1.45[abc]
3	Casoron		18.55[a]	22.15	40.70[a]
4	Karsil + Simazine	Karsil	0.35[a]	8.85[ab]	9.20[ab]
5	Karsil	Karsil + Simazine	0.03[a]	13.45	13.48[ab]
6	Simazine	Karsil	0.08[a]	0.35[ab]	0.43[abc]
7	Dinoben	Karsil + Simazine	0.00[a]	11.93	11.93[ab]
8	None - (Hoed Check)		0.00[a]	0.00[ab]	0.00[abc]
9	Dacthal + Simazine		12.03[a]	60.13	72.16[a]
		L.S.D.	32.56	48.52	39.15

[a]Denotes significance from check at 5% level.
[b]Denotes significance from treatment 9 at 5% level.
[c]Denotes significance from treatment 3 at 5% level.

The following treatments gave a significant reduction in grasses over the non-hoed check and Dacthal plus Simazine treatments:

6 - Simazine followed by Karsil.
2 - Eptam followed by Karsil + Simazine.
4 - Karsil + Simazine followed by Karsil.

Treatments 6 and 2 were considered excellant since they averaged only 0.35 and 1.30 pounds of grasses, respectively, per plot 9' x 12' compared to 58.30 pounds for the non-hoed check.

All the herbicide treatments gave a significant reduction in broad-leaved weeds over the non-hoed check. The following treatments had an average of less than 0.35 pounds of weeds per plot and would be considered clean for all practical purposes:

7 - Dinoben followed by Karsil + Simazine.
5 - Karsil followed by Karsil + Simazine.
6 - Simazine followed by Karsil.
2 - Eptam followed by Karsil + Simazine.
4 - Karsil + Simazine followed by Karsil.

The average combined weight or average total weight of weeds justify the following comparisons. All herbicide treatments produced a significant degree of weed control compared to the non-hoed check. In addition the following treatments were significantly better than the Dacthal plus Simazine treatment:

6 - Simazine followed by Karsil.
2 - Eptam followed by Karsil + Simazine.
4 - Karsil + Simazine followed by Karsil.
7 - Dinoben followed by Karsil + Simazine.
5 - Karsil followed by Karsil + Simazine.

In Table 3 comparisons are made between the number of strawberry plants just before treatment (June 19) and the number of plants in each treatment on September 15, 1960. Plant stands were significantly poorer in September in the Casoron and non-hoed check plots as compared with the following treatments:

6 - Simazine followed by Karsil.
2 - Eptam followed by Karsil + Simazine.
7 - Dinoben followed by Karsil + Simazine.
8 - Non-hoed check.
9 - Dacthal + Simazine.
4 - Karsil + Simazine followed by Karsil.

In addition the stand in the non-hoed check was significantly lower than treatment 5--Karsil followed by Karsil + Simazine. The latter (treatment 5) had a decreased stand as compared with treatment 6--Simazine followed by Karsil.

Table 3. Total strawberry plant counts in plots before application of herbicides (June 19) and on September 15, 1960.

Treatment number	Herbicide used on: June 20-21, 1960	Herbicide used on: July 21, 1960	Total plant count in four replications[a]: June 19, 1960	Total plant count in four replications[a]: September 15, 1960	Av. number of runner plants per original plant set
1	None - (Non-hoed check)		51	175[b]	2.4
2	Eptam	Karsil + Simazine	51	646	11.7
3	Casoron		52	229[c]	3.4
4	Karsil + Simazine	Karsil	54	491	8.1
5	Karsil	Karsil + Simazine	60	403[d]	5.7
6	Simazine	Karsil	51	686	12.5
7	Dinoben	Karsil + Simazine	58	620	9.7
8	None - (Hoed check)		56	588	9.5
9	Dacthal + Simazine		52	511	8.8

[a] These figures are actual stand counts. Since plant counts or stand counts are not normally distributed it is necessary to transform the plant counts by adding one to each plot count and then taking the square root when making statistical analyses.

[b] Denotes significant reduction in plant numbers over all other treatments at the 5% level.

[c] Denotes significant reduction in plant numbers over all other treatments except treatments 5 and 1 at the 5% level.

[d] Denotes significant reduction in plant numbers over treatment 6 at the 5% level.

The average number of runner plants formed per original plant set (Table 3) was low in the non-hoed check, Casoron, and Karsil followed by Karsil plus Simazine treatments with 2.4, 3.4, and 5.7 runner plants per original plant, respectively. Treatment 6 - Simazine followed by Karsil - and treatment 2 - Eptam followed by Karsil plus Simazine - had 12.5 and 11.7 runner plants, respectively. All other treatments were similar to the check - 9.5.

Plant observations throughout the season did not reveal any marked plant injury although occasional leaves in plots receiving both Karsil and Simazine had small amounts of chlorosis.

The most common broad-leaved weeds in the non-hoed check plots and in the border around the strawberry planting were: redroot pigweed, purslane, ragweed, lambsquarters, and smartweed. Most common grasses were: spreading witch, crab, and barnyard. By the end of August, redroot pigweed plants in the non-hoed check plots were often 4 to 6 feet tall while spreading witch grass was 3 to 4 feet tall. In the non-hoed checks, Casoron, and Dacthal plus Simazine plots, the grasses and broad-leaved weeds were so dense that the entire plots were covered and the strawberry plants were shaded. The summary of the principal weeds in the plots just before they were pulled and weighed in late August to early September is given in Table 4.

By using certain combinations of herbicides during the past season, more specifically between June 20 and September 1, it was possible to keep the strawberry planting free from serious weed competition without appreciable injury to strawberry plants. No attempt was made to use herbicides before June 20 this season because weeds can be controlled until then without much detailed hand weeding and more strawberry plant injury might occur from the earlier application. The success of these herbicide combinations may also have been largely due to the lack of soil disturbance. If the soil is cultivated or mixed additional weed seeds may be placed in a favorable environment for growth. The herbicides may be relocated where they will not control weeds as well or even be moved nearer certain plant roots and cause plant injury.

Table 4. Kind and relative amount of weeds in strawberry herbicide plots.

Treatment number	Herbicide used on: June 20-21, 1960	Herbicide used on: July 21, 1960	Kind and relative amount of weeds August 30 - September 8, 1960. Broad-Leaved Relative amount	Kind and relative amount of weeds August 30 - September 8, 1960. Grasses Relative amount
1	None-(non-hoed check)		PIGWEED (L),[a] purslane (L), ragweed (M), smartweed (M), lambsquarters (L) P, VP, 2EP[b]	WITCH (L),[a] crab (M), barnyard (M) P, VP, 2EP
2	Eptam	Karsil + Simazine	purslane (T) 3VG, G	unidentified (T-M) VG, 2G, F
3	Casoron		PURSLANE (L), pigweed (M) 3P, VP	WITCH (M), crab (M) 3P, VP
4	Karsil + Simazine	Karsil	purslane (T-S), ragweed (T) 3VG, G	WITCH (S-M), crab (M) VG, G, F, VP
5	Karsil	Karsil + Simazine	purslane (T) 4VG	WITCH (S-M) VG, G, P, VP
6	Simazine	Karsil	purslane (T) 4VG	unidentified (T-S) 2VG, 2G
7	Dinoben	Karsil + Simazine	none 4VG	WITCH (T-M), crab (S-M) 2VG, P, VP
8	None-(Hoed Check)		hoed	hoed
9	Dacthal + Simazine		PURSLANE (M-L), ragweed (S) 2F, P, VP	WITCH (L), crab (M-L) P, 3EP

a If broad-leaved weeds or grasses were present in large numbers and of medium to large size the weed is written in CAPITAL letters. The letter in parentheses following the weed describes their general size: L = large, M = medium, S = small, T = tiny, with only 3 to 6 small leaves, and S-M would indicate a range in size from small to medium.

b Key to relative amount of weeds:
A. The number indicates the numbers of plots involved out of four, if more than one.
B. The letters indicate the relative number of pounds of weeds in each plot, 9' x 12'.
VG = 0.2 pounds or less.
G = 0.5 to 1.5 pounds.
F = 1.6 to 3.5 pounds.
P = 11 to 21 pounds.
VP = 25 to 50 pounds.
EP = more than 55 pounds.

SUMMARY

The following herbicide treatments were effective in controlling broad-leaved weeds and grasses in a strawberry planting from June 21 to September 1.

Treatment 6 -- Simazine 1.5 lb/A on June 21, followed by Karsil 4 lb/A on July 21.

Treatment 2 -- Eptam 6 lb/A on June 20, followed by Karsil 4 lb/A + Simazine 1.5 lb/A on July 21.

Treatment 4 -- Karsil 4 lb/A + Simazine 1.5 lb/A on June 21, followed by Karsil 4 lb/A on July 21.

In addition, the following two herbicide treatments were effective in controlling broad-leaved weeds and would probably be satisfactory for general weed control if grass control were not a serious problem.

Treatment 7 -- Dinoben 4 lb/A on June 21, followed by Karsil 4 lb/A + Simazine 1.5 lb/A on July 21.

Treatment 5 -- Karsil 4 lb/A on June 21 followed by Karsil 4 lb/A + Simazine 1.5 lb/A on July 21.

The foregoing treatments gave satisfactory weed control without readily apparent injury to strawberry plants and without reducing the plant stand to a significant extent.

ACKNOWLEDGEMENTS

The authors are indebted and grateful to Dr. R. S. Dunbar, Statistician, West Virginia University, for the analyses of data.

The cooperation of the following companies in supplying the herbicides used in this experiment is also gratefully acknowledged: Amchem Products, Inc., Diamond Alkali Company, Geigy Agricultural Chemicals, Niagara Chemical Division of Food Machinery and Chemical Corporation, and Stauffer Chemical Company.

Maleic Hydrazide for Weed Control in Cranberries

C. E. Cross and I. E. Demoranville[a]

Introduction

Some field experiments with maleic hydrazide were set out on cranberry vines shortly after World War II. These were designed to assist the early coloring of the fruit, and to test the possibility of controlling such annual grasses as Digitaria and Aristida. The chemical showed little promise in either direction. In 1956, Dana (1) reported the selective control of sensitive fern, Onoclea, in Wisconsin cranberries. Dana (2) in 1960, further indicated control of perennial smartweed (Polygonum) and possible control of marsh St.Johnswort (Hypericum virginicum) using 10 lbs. actual MH-30 per acre, but indicated some injury to flower buds in the succeeding year. Marucci and Moulter (3) have succeeded in reducing the length of runner growth of New Jersey cranberry vines by mid-season treatments of maleic hydrazide and without adverse effects on fruit production.

Methods

In July and August, 1959, several series of ½-rod plots were set out on various cranberry bogs in Barnstable County. These were set out under conditions of high relative humidity to determine the effectiveness of several rates of maleic hydrazide primarily on feather fern (Thelypteris), sensitive fern (Onoclea), royal and cinnamon ferns (Osmunda sps.), and wild bean (Apios). Rates of 5, 10 and 15 lbs. actual per acre were used, the material mixed with water and applied at the rate of 300 gallons an acre with a knapsack sprayer.

In mid-April, 1960, a series of plots was set out on a so-called "dry bog" to test the possibility of inhibiting bud development sufficiently to prevent or reduce injury from late April and May frosts.

Beginning in June, 1960, several series of test plots, and some small commercial-sized plots were set out with knapsack and power sprayers using various rates up to 15 lbs. actual/acre, and using 100 to 300 gals. of solution per acre, and set out on a great variety of weed species.

Results and Conclusions

A. The crop plant.

None of the plots so far treated has been followed by any apparent injury to cranberry vines. Applications in April retard bud development to some extent over a period of 3 or 4 weeks, but actual blooming time is delayed by one week or less, and the flowering and set of fruit appeared normal.

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Blooming period (late June, early July) sprays up to 15 lbs. actual MH/acre had no apparent effect on flowers, fruits or the tender new vegetative growth of cranberry vines. Similarly, the late July and early August treatments caused no discoloration or disfiguration of cranberry vines or their developing fruits. However, the year following August applications, especially those at 12 and 15 lbs. actual MH/acre, the number of blossoms was reduced by up to 50%. July applications at the same rates showed little or no tendency to reduce the bloom of the following year, and in some cases apparently augmented it. In a few tests in 1960, late July treatments with MH actually showed an increased production of cranberries in the fall of 1960.

It can be concluded, therefore, on the basis of tests during two successive growing seasons, that maleic hydrazide at rates up to 15 lbs. actual/acre is not injurious to cranberry vines when applied at any time during the growing season. Blossom production the following year is likely to be reduced by high rates applied in early August.

B. Weed Control

All four of the above-named ferns found commonly on Massachusetts cranberry bogs showed the effects of MH treatment. After taking on a rusty appearance following July and early August treatment, they came back the following year in dwarf and malformed condition. The sensitive fern only appeared reduced in numbers. The royal ferns, the year following treatment, were small, malformed and inclined to be chlorotic.

Following treatment in July or August, wild bean plants slowly became sickly, rusty in appearance and finally, at harvest time (mid-September), dried up without having produced the characteristic flower clusters. The following year only widely-scattered, dwarfed shoots of wild bean grew up in plots treated the preceding July, and not even these appeared in plots treated the preceding August. The combined August plots on several cranberry bogs showed over 90% control of this weed.

Most startling, however, was the failure of rice cutgrass (Leersia) to come up in the bud inhibition plots treated in mid-April, 1960. At the 12 and 15-lbs./acre rate, cutgrass failed to appear throughout the 1960 growing season. The same can be said for this grass, which was present to a more limited extent, in the fern plots treated in July and August 1959. When cutgrass is sprayed in mid-summer with 9 to 15 lbs. MH/acre, the grass leaves slowly turn yellowish and in late summer dry up. These higher dosages appear to inhibit the buds on the rhizomes from producing new grass tops for at least a 12-month period. Tests at 6 lbs. actual/acre were somewhat less effective, and like the ferns, dwarf and off-color sprouts developed.

To conclude, a treatment of 15 lbs. actual MH-30 acre applied in late July or early August kills over 90% of wild bean and rice cutgrass and does this essentially without injury to cranberry vines.

1. Dana, M. N. Sensitive Fern Control in Cranberries. North Central Weed Control Conference, pp. 152-153, Dec. 1956.

2. Dana, M. N. Personal correspondence.

3. Marucci, P. E. and Moulter, H. J. The Suppression of Cranberry Runner Growth by Maleic hydrazide. Proc. American Cranberry Growers Assn. Feb. 7, 1957.

RESIDUE REPORT ON APPLES HARVESTED FROM TREES WHERE AMINO TRIAZOLE SPRAYS HAVE BEEN APPLIED TO THE GROUND COVER.

Oscar E. Schubert[1]

In 1957, an experiment was initiated at the West Virginia University Horticulture Farm near Morgantown, to ascertain the effects of several herbicides on apple trees (1). With more frequent use of herbicides additional information would be needed regarding their harmful or beneficial effects upon tree and fruit growth. Since the tolerance of plants to herbicides is often critical, herbicides were applied at the commonly recommended rates and at rates five times greater. An orchardist or his workers would be more likely to overspray, by trying to cover the area thoroughly or by a calibration error, than he would by adding five times as much of the herbicide to the spray tank. For these reasons the application rates were 200 gallons per acre for the basic rate and 1000 gallons per acre for the five fold rate.

Amino triazole was included in the foregoing experiment at rates of 4 and 20 pounds of active ATA per acre. An area of 1/100th acre was sprayed as uniformly as possible using a three nozzle boom delivering the spray in a flat fan pattern. A power sprayer was used to maintain the pressure at 75-80 pounds while spraying. Applications were made in each of three years--July 11, 1957, July 24, 1958 and June 29, 1959. In 1959, the Golden Delicious trees were 11 years old and the Stayman were 22 years old.

Apples which were later used for amino triazole residue analyses were taken from samples of fruit harvested for storage studies. One bushel samples of mature fruit were picked at random from all parts of each tree. If the crop was less than one bushel, all apples were taken. Random sub-samples of these storage samples were sent to the C. W. England Laboratories[2] for amino triazole analyses at the request of Truman Nold, National Apple Institute.[3]

The first analyses were made by using the chromotropic acid determination or the method used previously for cranberries and are shown in Table 1.

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[3]The author is indebted to the National Apple Institute for bearing the cost of the analyses and to Truman Nold for making all necessary arrangements.

Table 1. Amino triazole residue analyses[a] of Stayman and Golden Delicious apples harvested from trees where the ground cover had been sprayed with amino triazole.

Variety	Rate of ATA[b]	Number of sprays[c]	ATA residue (ppm)	Tree[d]	Sample number
Stayman	0	0	0.00	C-R5T10	5
Stayman	4	3	0.05	C-R13T6	6
Stayman	4	3	0.00	C-R13T2	2
Stayman	20	3	0.00	C-R16T9	8
Stayman	20	3	0.09	C-R12T13	1
Golden Delicious	0	0	0.08	K-R5T20	3
Golden Delicious	4	3	0.09	K-R5T4	4
Golden Delicious	20	3	0.06	K-R5T19	7

[a]Chromotropic acid determination of ATA residue made by C. W. England Laboratories on December 14, 1959.
[b]Number of pounds per acre of active ATA sprayed beneath trees.
[c]Applied July 11, 1957, July 24, 1958, and June 29, 1959.
[d]Block - row and tree number to identify tree.

According to the C. W. England Laboratories, "The U. S. Food and Drug Administration considered any sample which has a response of less than 0.15 p.p.m. as negative. Apple pigments and other material in apples are known to come through and give low false positive responses." If Stayman samples 5,6, and 1 are compared with each other, disregarding sample 2 and 8 with 0.00 residues, it may appear that a relationship exists between rate of ATA application and ATA residue in the fruit. In these three samples from 0,4, and 20 pound per acre tree plots the ATA residues were 0.00, 0.05, and 0.09 p.p.m., respectively. This might indicate an uptake and translocation of small amounts of ATA to the fruit. With this possibility in mind, chemists at the Food and Drug Administration developed a more sensitive method for ATA determinations known as the FDA Rapid Method using the Bratton-Marshall procedure.

The need for a modified procedure was also indicated by adding known amounts of ATA to the apple while they were being prepared for analyses and then determining the quantities of the added ATA which were recovered in the analyses (Table 2).

Table 2. Recovery[a] of added amino triazole by the chromotropic acid determination of ATA on Golden Delicious apples from an untreated tree.

Amount of ATA added in p.p.m.	Unknowns read against reagent blank		Unknowns read against apple blank	
	ATA (ppm)	Per cent recovery	ATA (ppm)	Per cent recovery
0	0.056			
0.10	0.064	8.0	0.03	3
0.15	0.064	5.4	0.04	4
0.50	0.404	80.8	0.39	78

[a]Report from C. W. England Laboratories on December 24, 1959.

Additional apple samples were provided for amino triazole determinations by the FDA Rapid Method using the Bratton-Marshall procedure and are reported in Table 3.

Table 3. Amino triazole residue and recovery analyses[a] of Stayman, Golden Delicious and Rome apples.

Variety	ATA treatment rate in orchard	ATA (ppm)	Recovery of added ATA: Amount of ATA added (ppm)	ATA Recovered (ppm)	Per cent Recovery[b]	Tree
Stayman	0	0.001	0.15	0.09	60	C-R5T10
			0.25	0.21	84	
			0.50	0.457	91	
Stayman	0	0.011	0.25	0.234	89	C-R16T8
Stayman	4[c]	0.012	0.25	0.214	80	C-R13T2
Stayman	20[c]	0.038	0.25	0.249	84	C-R12T13
Golden Delicious	-	0.08	0.15	0.10	67	Market Purchase[d]
			0.25	0.20	80	
			0.50	0.42	84	
Golden Delicious	4[c]	0.083	0.25	0.311	91	K-R5T4
Rome	0	0.037	0.25	0.27	97	K-R4T21
Rome	20[c]	0.053	0.25	0.278	90	K-R4T22

[a] Analyses by C. W. England Laboratories with the FDA Rapid Method using the Bratton-Marshall procedure for amino triazole.
[b] Controls were subtracted before recoveries were calculated.
[c] The ground cover beneath each of these trees was sprayed in 1957, 1958, and 1959.
[d] Samples of Golden Delicious on market presumably from trees where amino triazole had not been used.

From the analyses presented in Table 3 no relationships in amino triazole residues are apparent between apples from trees where amino triazole had been sprayed beneath them and from untreated trees. Differences between varieties have not been accounted for except to postulate that some varieties have more amino-like compounds present in the fruit than do other varieties.

1. Schubert, Oscar E. 1959. Effect of recommended and excessive rates of certain herbicides to apple trees of varying ages. Proc. 13th Annual Meeting NEWCC: 62-63.

Weed Control and Residual Effects of Simazine and of Atrazine Applied to Sod Prior to Planting Nursery Stock

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As reported in January 1960, a field of predominantly timothy sod was marked off in June 1959 into plots 10' x 10'. These plots were arranged so that alternate blocks of two rows could be rototilled after treatment with herbicide. The remaining rows were treated with herbicide but not rototilled. In June of 1960 half of each plot of adjoining pairs was rototilled. The rototilling was parallel to that done in 1959. The original plots were thus split in half. See Table 1. Untreated check rows crossed blocks every third row, thus each treatment was adjacent to a check or plot free from herbicide.

Table 1. Control of original grass based on rating of reduction in turf density - 0 to 10 maximum reduction or zero turf.

Herbicide treatment	End of first season, 1959: not roto-tilled	End of first season, 1959: roto-tilled 1959	End of second season, 1960: not roto-tilled	End of second season, 1960: roto-tilled 1959 only	End of second season, 1960: roto-tilled 1959 and '60	End of second season, 1960: roto-tilled 1960 only
Untreated or check	1.8	9.1	0.8	7.1	9.6	9.1
Simazine						
5# A/A spray	7.6	10.1	3.4	7.0	9.8	9.5
gran.	4.6	9.5	5.0	9.1	9.9	9.5
10# A/A spray	9.6	10.0	7.4	9.7	9.7	9.5
gran.	7.0	10.0	8.4	9.7	9.9	9.9
Atrazine						
5# A/A spray	9.5	9.7	4.7	8.0	9.7	9.5
gran.	8.9	9.7	8.4	8.7	9.7	9.5
10# A/A spray	9.6	10.0	8.5	9.5	9.7	9.5
gran.	10.0	10.0	9.5	9.4	9.5	9.5

Rototilling with a 24" tiller, Howard Rotary Hoe, reduced the density of the original grass stand by 90% or more both in 1959 and in 1960 (see Table 1). Plots rototilled in 1959 but not in 1960 showed some re-establishment of orchard and of quackgrass during 1960. An exception occurred when 10 pounds of active herbicide per acre was used in combination with rototilling. These plots remained essentially weed-free. Herbicides used at the 5 pound level of active ingredient per acre as granular formulations were more consistently effective than 5 lbs. A/A wettable powder formulations in reducing stands of perennial grasses. Hedge bindweed developed in dense stands in all plots from which turf was reduced by half or more.

The herbicides Simazine and Atrazine applied to turf without rototilling or mechanically disturbing the soil surface resulted in appreciable reduction in grass stand. Wettable powder formulations were consistently more effective immediately following application in 1959 but were less effective than granular formulations in the year following application, i.e. 1960 compared to 1959. Thus granular formulations in this test had longer or greater residual effect than wettable powder.

The most effective combination of treatments in the present experiment is the combination of the herbicide followed at once by rototilling.

Residual action of herbicides

The primary objective of rototilling in 1960 was to provide a seed bed for test crops. These crops included buckwheat and oats. Both species of the ornamental crops *Ligustrum ovalifolium* and *Euonymus fortunei* are sensitive to Simazine. They were set out bare root for maximum exposure of roots to residual herbicide. *Forsythia intermedia* "Spring Glory and *Pachysandra terminalis* were also included in field planting.

In October 1960 soil samples were taken and planted to kidney beans in the greenhouse as a final bioassay for residual effect of the herbicides Simazine and Atrazine.

Observations made in early August on discoloration in the seedling stage of buckwheat and oats or in the young foliage of Euonymus indicated clear response only with Simazine at the 10 pound rate of the granular formulation. Response to Atrazine was found in the 10 pound rate in the twice rototilled plots for both liquid and granular formulations. Not all plants of a kind in these plots showed response. Usually less than half of the plants showed yellowing of seedling leaves only or of new foliage formed after planting.

Later season results in November indicated less response except with the Euonymus. Mature foliage of oats and buckwheat were normal. The test plants grew essentially as well as the normal non-yellow controls. Seedling beans showed no indication of abnormal growth in soil samples taken in October 1960 after herbicide application in July 1959.

Residual action in clay loam may be effective in deterring immediate regrowth of grasses. Bindweed and Canada thistle, dandelion, and plantain appeared in 1959 and continued in 1960 unless rototilling was done. In this case regrowth was reduced in amount or to seedling stage. Residual action in 1959 or in 1960 was not adequate to prevent the establishment of annual grasses and other weeds.

Perennial weeds, including grasses, bindweed, dandelion, plantain, carrot and New England aster were numerous in plots rototilled in 1959 but not in 1960.

None of the weeds common to both control and treated plots showed evidence of residual Simazine or Atrazine beyond large and vigorous plants of dandelion. These were often darker green than normal. This color may be more nearly the result of release from competition than a specific effect of the herbicide.

Summary

Residual action of Simazine or Atrazine did not appear to be severe enough to eliminate plant growth or re-invasion of treated plots by annual and perennial weeds.

In other tests re-invasion of treated areas by quackgrass has been retarded for a year or more. Evergreen nursery crops such as Taxus, arborvitae and juniper, treated as established plants have continued to grow without obvious or prolonged injury following use of Simazine and Atrazine in amounts of 5 to 10 pounds of active ingredient per acre. The combination of the herbicide and cultivation technique may well be adequate for practical purposes of control for quackgrass and some other perennial weeds in plantings of established evergreen trees and shrubs. Other practical uses would be cleaning up rough sod prior to planting ground covers where it is desirable to have two or more years of minimum weed growth for maximum rate of establishment of clumps or potted planting units of ground cover. Renovation of weedy stands of roses, peonies and other ornamentals is a third possibility. The continued effectiveness of control from the combination of herbicide and cultivation is important as a means of reducing the surface movement of herbicide on slopes due to rain or melting snow.

HERBICIDES FOR YOUNG APPLE TREES

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The successful establishment of an apple orchard is closely associated with the growth of the trees during their first few years in the orchard. After the trees have been planted, one of the important factors in stimulating growth is the adequate control of weeds around these young trees. The use of chemicals for this purpose offers considerable promise and several advantages over the tedious and expensive method of hand hoeing in areas where machine hoeing is impossible or difficult.

Previous work at Arendtsville and elsewhere has suggested the value of using certain chemicals for weed control around young apple trees. This year an opportunity was available to test these suggestions on a larger scale than had previously been possible. In the spring of 1960, one hundred and thirty two 2-year-old Delicious apple trees were set out for the express purpose of testing herbicides around young trees. These trees were planted 5 feet apart on April 19 in holes dug by a 14 inch auger. All trees were cut back to 3 feet.

At the time the treatments were applied on June 2, some weeds had grown up around the trees. In order to have a more complete evaluation of the materials used in this experiment, trees were paired. The first tree in each pair was hand hoed just previous to being sprayed, so was weed free, and is thus designated as "clean"(C) in the table of results. The second tree in the pair was left untouched, so that weeds were present at the time of treatment, and is therefore designated as "weedy"(W) in this table. No further cultivation was done around these trees. The materials used in this experiment were applied with a small hand operated pressure sprayer, modified so that exactly one pint of spray could be applied per tree over an area of 10 square feet. This amount per tree would be equivalent to 550 gallons per acre, or about ten times the usual spray coverage for field applications. This relatively large amount of spray provided much better coverage of the plot area than would have been possible with smaller amounts of spray. Treatments were replicated four times. Notes and pictures were taken during the season, and on November 11 the treatments were evaluated for weed control by estimating the percent weed control around each tree. The results of this evaluation, together with the materials and rates used, are shown in Table I. Later in the month, tree height and terminal growth measurements were taken. These data are also shown in Table I.

Under the conditions of this experiment, the use of Dalapon by itself or in combination with Amitrol T gave little if any weed control. Amitrol T by itself also gave negligible weed control. The predominant weeds around these trees, however, were broadleaf, which would account for the poor showing of Dalapon, a grass or narrow leaf herbicide. In contrast, Simazine at the 2 and 3 lb. rate gave fair weed control on the "clean" plots, but little on the "weedy" plots. However, when Simazine and Amitrol T were used together in various combinations, they were much more effective on the "weedy" as well as on the "clean" plots than when used alone. It is apparent that these two materials are synergetic, the one increasing the efficiency of the other. As might be expected, better results with this combination and others were found on the "clean" plots. This is the condition that would exist if the trees had been sprayed soon after planting, and thus points to even better results if these materials were used earlier in the season.

The amount of tree growth, as shown in Table I, is closely associated with the success of the weed control treatments. Tree height and terminal growth measurements clearly show the stimulating effects of good weed control around young apple trees, which is most evident in the Amitrol T and Simazine combination spray treatments. When these trees were examined on November 11, the leaves of trees in the Amitrol T and Simazine combination spray plots were still quite green, whereas those in the other treatments were brown or on the ground.

Variations in rainfall during the growing season have marked effects on herbicide action to weeds and crops. In the year of this experiment, the rainfall in May was 6.11 inches, or 2.00 inches above normal. In the subsequent months from June to September, the total rainfall measured at Arendtsville was nearly normal, amounting to 15.11 inches as compared to the twenty five year mean of 15.12 for this period. Thus 1960 could be considered almost a "normal" year as far as the amount of rainfall and it's distribution were concerned.

The results of this experiment indicate that the use of Amitrol T and Simazine combination sprays, in a year of average rainfall, can be an effective practice in controlling weeds around young apple trees and thus in stimulating early development of the new apple orchard.

Table I. Weed Control and Tree Growth of Two-year Old Apple Trees Receiving Various Herbicides.

Treatments No.	Material	Rate lbs./A*	Soil Cond. (1)	Weed Control (%)	Tree Growth Height (in.)	Tree Growth Terminal Growth (cms.)
1	Amitrol T	1	C	0	50.2	143.5
			W	0	53.0	129.7
2	do	2	C	0	49.0	197.7
			W	0	45.0	125.8
3	do	4	C	2.0	46.2	105.5
			W	0	44.0	121.5
4	Dalapon	5	C	18.0	46.0	147.2
			W	15.0	44.8	111.2
5	do	10	C	15.0	50.0	184.0
			W	28.0	47.8	120.8
6	do	20	C	8.0	43.5	115.0
			W	5.0	43.0	109.8
7	Simazine	1	C	32.0	53.2	154.5
			W	15.0	48.5	112.2
8	do	2	C	62.0	56.8	292.2
			W	10.0	55.2	175.5
9	do	3	C	72.0	48.5	170.5
			W	8.0	46.8	148.2
10	Amitrol T	2	C	73.0	62.0	303.0
	Simazine	2	W	45.0	62.5	294.0
11	Amitrol T	2	C	90.0	65.5	313.5
	Simazine	3	W	68.0	54.2	235.0
12	Amitrol T	4	C	80.0	58.5	264.8
	Simazine	2	W	72.0	70.0	304.8
13	Amitrol T	4	C	85.0	59.5	253.2
	Simazine	3	W	74.0	69.0	358.2
14	Dalapon	10	C	25.0	55.2	195.5
	Amitrol T	4	W	8.0	53.2	226.2
15	Dalapon	25	C	0	52.2	141.8
	Amitrol T	8	W	0	46.5	131.8
16	Check		C	0	45.2	103.2
			W	0	46.2	136.5

*Lbs. active material

[1] C - "clean" soil area
W - "weedy" soil area

Post-Hill Chemical Weed Control in Potatoes with Granular Formulations - by Arthur Hawkins /1

Comparisons were made of several granular formulations of chemicals applied on the day of final cultivation in a field of Katahdin potatoes where a heavy crabgrass population was expected and occurred later.

Materials and Methods

Granular materials listed in Table 1 were applied on July 1,1960 within three hours after the final cultivation to Katahdin potatoes. A cyclone seeder 2/ was used to apply Alanap and Falone on plots 4 rows x 100 feet. The other materials were broadcast from a paper bag by hand on plots 3 rows wide and 24 feet long. Three or four row checks were left to either side of each treatment. No provision was made to brush granules off plants. The soil was moist at the time of application, 1" of rain had occurred the two previous evenings. On the evening of July 1, there was 1.3" of rain; 2½" occurred on July 14; 1.4" fell on July 27.

Results and Discussion

Effect of Materials on Potatoes - Considerable damage to potato leaves and stalks occurred from DNBP granules which remained on the plants. Severe damage occurred to the base of some stalks where granules had accumulated at the soil line.

Leaves of potatoes treated with Alanap showed 2-4-D type injury within a few days after treatment. Potatoes on falone treated plots showed the same type of injury but to a lesser degree, see Table 1.

Leaf absorption had occurred since granules were not brushed off the foliage. At another location where granules of Falone were not brushed off some leaf injury was noted within two days after application, no rainfall having occurred. This symptom persisted into early August probably as a result of the leaching rains.

Randox T injury,noted shortly after treatment, became increasingly severe by August 1, and persisted throughout the season. Esteron caused severe injury.

Effect on Weeds - A high population of crabgrass occurred where not controlled and grew rapidly late in August and early September. Weed control was rated early in the season and on Sept. 15, see Table 1.

Falone at 4 lbs. per acre gave good control of grass; it was also superior to Alanap at another location. Randox, Zytron and Vegedex gave very promising results especially at the higher rates at this and at another location. Dalapon gave good control.

Yields were obtained only on plots of those treatments which did not seriously injure potatoes and where sprayer wheels had not passed. The yields are for only a few treatments and on only single plots.

1/ Agronomist and Extension Potato Spec., Univ. of Conn.,Storrs,Conn.

2/ George O'Brien and P.W. Bohne, Naugatuck Chem. Co., cooperating.

Table 1 -Effect of Granular Formulations of Herbicides Applied at Layby on Crabgrass Control and Katahdin Potatoes - Connecticut 1960.

Chemical	Active lbs/A.	Injury to 1/ Potato plants 7/6	8/1	Crabgrass Control % of Check 8/1	9/15	Yield 2/ % of Check
Alanap 10G	4	1.5	1.5	95	70	
Dalapon 10G	4	0	0	75	75	
	8	0	0	95	95	
Falone 10G	4	1	1	95	85	109
DNBP 10G	4	4	2	80	70	
	8	4	2	95	85	
Randox 20G	2	0	0	85	75	144
	4	0	0	95	90	118
Randox T 20G	2½	3	4	70	70	
	4½	3	4	95	90	
Vegedex 20G	2½	0	0	85	80	
	5	0	0	90	85	113
Zytron 25G	10	0	0	90	80	123
	15	0	0	100	90	129
Esteron G 2,4-D	½	2	2	50	50	
	1	5	4	70	50	
	2	5	4	80	80	

1/Injury Rating: 0-no injury noted, 5-Severe

2/ Yield data were obtained only on plots where treatments did not seriously injure potatoes and if the plot had no sprayer wheel track damage. Yield of treated plot in per cent of yields of checks on each side.

SUMMARY

Falone at 4 lbs. gave longer residual control of crabgrass and caused less injury to potatoes than Alanap at 4 lbs. Randox at 2 to 4 lbs., Dalapon at 4 to 8 lbs., Zytron at 10 to 15 lbs. and Vegedex at 2½ to 5 lbs. gave good to excellent control of crabgrass. The above observations were generally true for control at another location where some broadleaved weeds and barnyard grass was also present.

Randox T was injurious to potatoes at only 2½ lbs. per acre.

Some means should be employed to brush granular formulations of some chemicals from the plant to reduce injury from leaf absorption.

Progress Report on Lay-By Weed Control of Potatoes[1]

R. L. Sawyer and S. L. Dallyn

This report is a continuation of work included in previous proceedings concerning chemicals applied to potatoes to control the weeds which become a problem after last cultivation.

Materials and Methods: All materials were applied in granular form using a Noble applicator. Plots were three rows wide and 30 feet long, replicated four times. Thirty-two check plots were randomized through the experiment, the average being given in table 1. Rye was sown as a grass weed crop on June 21 and the Eptam plots treated before the last cultivation. The remaining chemicals listed in table 1 were applied to Katahdin potatoes on June 23 after the last cultivation. Potatoes were harvested on September 7.

Results and Discussion: Atrazine at both the two and four pound rates gave foliage burns and decreased the yield of potatoes. Karmex also gave slight foliage burn and a yield reduction.

The rye crop seeded for weed control determination gave a very poor stand and no results in weed control ability were obtained.

Table 1. Chemicals applied as granular form for lay-by weed control with potatoes.

Material	Active Rate lbs./A.	Bu./A. Yield	Specific Gravity
Eptam	2	694	1.055
Eptam	4	609	1.060
Simazin	4	621	1.057
Falone	4	694	1.062
Karmex DW	3/4	489	1.054
Dalapon M1501	1	643	1.060
Dalapon M1501	3	617	1.063
Alanap	3	639	1.062
Amiben	2	685	1.063
Amiben	4	651	1.063
Atrazine	2	200	1.047
Atrazine	4	136	1.055
Check		669	1.060

		Mean Squares	
Source	DF	Bu./A. Yield	Specific Gravity
Replication	3	204.0	44.33
Treatments	19	659.0	28.68
Error	57	265.3	27.60

1 Long Island Vegetable Research Farm, Cornell University, Riverhead, N. Y. Paper No. 446, Department of Vegetable Crops, Cornell University, Ithaca, N. Y.

EVALUATION OF FIVE HERBICIDES FOR KILLING ESTABLISHED POISON IVY IN AN APPLE ORCHARD THREE YEARS FOLLOWING A SINGLE TREATMENT.

Oscar E. Schubert[1]

This study is being continued to determine the number of years a single herbicide application will give a significant reduction in poison ivy when compared with unsprayed checks. Additional details of the experiment and yearly results have been reported in the Proceedings of the Northeast Weed Control Conference (1, 2).

Between August 13 and 17, 1957, ATA, 2,4,5-T Ester, 2,4,5-TP 2,4,5-T Amine, and Ammate were applied to well established poison ivy in a mature apple orchard. All herbicides, except Ammate, were applied at the rate of 4 pounds active ingredient per acre. Ammate was applied at the rate of 150 pounds of formulated Ammate per acre. The herbicides were applied with a power sprayer at the rate of 200 gallons of spray per acre. An operating pressure of 75-80 pounds was applied to the three nozzle boom delivering a flat fan spray pattern.

The 1/100th-acre plots were classified according to the relative density of poison ivy, and then grouped into twelve replications, each with similar poison ivy stands. Six replications composed of six plots each were laid out around trees, and another six replications were laid out in spaces between tree plots in the tree row. The herbicides were applied at random within each replication.

All sprayed plots were free of poison ivy when observations were made in October, 1957. In the fall of 1958, 1959, and 1960, the density of poison ivy was recorded for each of the 72 plots as the number of leafy stems that were visible. Stem counts of 20 to 50 would generally be considered light. The apparent decrease in average stem counts in 1960 compared with 1959 may have arisen from less frequent mowing of the orchard cover, hence a smaller number of branched stems. Differences in weather may also have influenced the stem counts. Since stem counts or stand are not normally distributed it is necessary to transform the stem counts by adding one to each count and then taking the square root when making statistical analyses.

In Table 1, the average number of poison ivy stems is given one, two and three years following the application of herbicides.

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1 Associate Horticulturist, West Virginia University. The author is indebted to Dr. R. S. Dunbar, Statistician, for the analyses of the data. He is also grateful to the Dow Chemical Company for 2,4,5-T compounds and to American Cyanamid Company for the ATA used in this study.

Table 1. Average number of poison ivy stems in six 1/100th-acre replicated plots one, two and three years following a single herbicide application (August, 1957) to established poison ivy in an apple orchard.

Year	ATA 4 lb/A[a]	2,4,5-T Ester 4 lb/A	2,4,5-TP 4 lb/A	Ammate 150 lb/A	2,4,5-T Amine 4 lb/A	Check
			Treatments Around Trees			
1960	22.5*	33.8*	52.3*	54.8*	69.0*	187.8
1959	26.0*	42.2*	76.3*	90.5*	111.5*	477.0
1958	0.3*	12.5*	12.0*	5.8*	12.5*	136.7
			Treatments Between Trees			
1960	15.3*	21.2	17.0*	31.7	30.2	112.5
1959	27.5*	35.0*	46.2*	44.2*	48.2*	233.0
1958	0.3*	2.8*	11.2*	2.2*	6.3*	55.0

a All herbicide rates were applied in 200 gallons of water per treated acre. Rates of all herbicides, except Ammate, are expressed as pounds per acre of active ingredient. Ammate is given as the number of pounds of formulated herbicide per acre.

* Denotes significance from check at the 5% level.

In each of the three years following the single application, ATA, 2,4,5-T Ester, 2,4,5-TP, 2,4,5-T Amine, and Ammate have given a significant reduction in number of poison ivy stems in plots around trees when compared with the check. The foregoing treatments have also given a significant reduction in poison ivy stems in plots between trees during 1958 and 1959, one and two years after treatment. In 1960, however, only ATA and 2,4,5-TP significantly reduced the number of stems in plots between trees.

1. Schubert, Oscar E. 1959. Comparisons of five herbicides used to kill established poison ivy in a mature apple orchard. Proc. 13th Annual Meeting NEWCC: 57-59.
2. ___________ 1960. Evaluation of five herbicides for killing established poison ivy in an apple orchard one and two years following a single treatment. Proc. 14th Annual Meeting NEWCC: 219-220.

PROGRESS REPORT ON WEED CONTROL IN CARROTS AND SQUASH

M.F. Trevett and William Gardner 1/

INTRODUCTION

This paper is a report on the effectiveness of certain herbicides listed in Table 1 in controlling annual broadleaf weeds in Golden Delicious squash and in Chantenay carrots.

Procedure

Treatments were replicated six times in randomized blocks of single row plots paired with untreated plots. Sprays were applied with a single pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. All plots were cultivated throughout the season, but during cultivation the soil was not disturbed six inches on either side of the crop row.

The principal broadleaf weeds in the carrot blocks were: Lambsquarters (Chenopodium album L.), Shepherd's Purse (Capsella Bursa-pastoris L.), and Foxtail (Setaria spp.).

The principal broadleaf weed in the squash block was Lambsquarters.

Results

A. Carrots.

Ten pounds per acre of Zytron applied pre-emergence resulted in significantly higher yields of carrots than pre-emergence application of 2 or 4 pounds of Amiben, or 4 pounds of granular CIPC, Table 2. Ten pounds of Zytron did not differ significantly in effect on yield from 4 or 8 pounds of Dacthal applied pre-emergence, or from 4 pounds of Karsil applied post-emergence. Four pounds of Trietazine resulted in yields significantly lower than all other treatments except check.

Highest yields were, in general, associated with treatments that ranked numerically high for both number of carrots per plot and weight per carrot, Table 1. Statistically, however, in the pre-emergence block, Zytron, Dacthal, Karsil, and Amiben did not

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differ significantly in number of carrots per plot, Table 3. Four pounds of Trietazine produced significantly fewer carrots than all other treatments, and 4 pounds of CIPC produced significantly fewer carrots than 4 pounds of Dacthal and 10 pounds of Zytron. Weight per topped carrot did not differ statistically in Zytron, Dacthal, Karsil, or Amiben plots. The high weight per carrot in Trietazine and CIPC plots can be attributed to decreased competition between surviving carrots resulting from reduction in carrot stand. Except for 8 pounds of Dacthal and 4 pounds of Trietazine, weed control ratings corresponded fairly well with yield, Table 2. Two pounds of Amiben did not give satisfactory weed control; all other treatments gave, at least, acceptable control, Table 5.

In a post-emergence test, 4 or 6 pounds per acre of Solan, 3, 4, or 6 pounds of Dicryl, and 3, 4, or 6 pounds of Karsil did not differ significantly in effect on yield, number of carrots per plot, or weight per topped carrot. All rates of these herbicides produced yields significantly higher than check, Table 6.

B. <u>Squash</u>

Pre-emergence application of 3 pounds per acre of DNBP, 10 pounds Zytron, and 6 pounds Amiben (granular) did not differ significantly in effect on either yield or number of gourds per plot of Golden Delicious squash, Table 7.

Gourd weight was significantly higher in DNBP, Zytron, and Amiben than in check plots. DNBP and Zytron did not differ significantly in effect, but average gourd weight was lower in Amiben than in DNBP plots. This difference in weight is presumably associated with difference in degree of weed control, Table 7.

Conclusions

Ten pounds of Zytron per acre, 4 to 8 pounds of Dacthal, and 4 pounds of Amiben show promise for pre-emergence application in carrots. Zytron, in the present test, was outstanding.

In post-emergence tests in carrots, Solan, Dicryl, and Karsil at rates from 3 to 6 pounds per acre, did not differ significantly in effect on yield, stand, or average weight per topped carrot. Karsil gave numerically lower yields than either Solan or Dicryl.

Pre-emergence application to Golden Delicious squash of 3 pounds of DNBP, 10 pounds of Zytron, and 6 pounds of Amiben did not differ significantly in effect on yield. Weight per gourd was significantly higher in DNBP than in Amiben plots. All herbicides produced significantly heavier gourds than check.

Table 1. Herbicides Used in Carrots and Squash, 1960.

Designation	Active Ingredient (AI)[1/]
Amiben	3-amino-2,5-dichlorobenzoic acid
CIPC	Isopropyl-n-(3-chlorophenyl) carbamate
Dacthal	Dimethyl 2,3,5,6-tetracthloroterephthalate
Dicryl	N-(3,4-dichlorophanyl) methacrylamide
DNBP	4,6-dinitro-o-sec-butylphenol
Karsil	N-(3,4-dichlorophenyl)-2-methylpentanamide
Solan	N-(3-chloro-4-methylphenyl)-2-methylpentanamide
Trietazine	2-chloro-4-diethylamino-6-ethylamino-5-triazine
Zytron	O-(2,4-dichlorophenyl)-o-methyliso-propyl-phosphoramidothioate

1/ AI = active ingredient
WP = wettable powder
GR = granular

Table 2. Carrot Yield Following Pre-Emergence Application of Various Herbicides.

Acre rate of herbicide (AI)		Pounds topped carrots per acre[2/]	Rank for:[3/] Number of carrots per plant	Weight per topped carrot	Weed control
10# Zytron,	pre[1/]	37710	2	2	2
8# Dacthal,	pre	32499	3	5	7
4# Karsil,	post	32306	4	3	3
4# Dacthal,	pre	31736	1	8	5
4# Amiben,	pre	29512	5	7	4
4# CIPC, granular	pre	27782	8	1	6
2# Amiben,	pre	26728	7	6	8
Check		19633	6	9	9
4# Trietazine		17274	9	4	1
L.S.D. 5%		6469			

1/ pre = pre-emergence; post = post-emergence.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

3/ 1 = highest; 9 = lowest.

Table 3. Number of Carrots Per Plot Following Pre-Emergence Application of Various Herbicides.

Acre rate of herbicide (AI)		Number of carrots per plot 1/
4# Dacthal,	pre	273
10# Zytron,	pre	265
8# Dacthal,	pre	254
4# Karsil,	post	242
4# Amiben,	pre	237
Check		221
2# Amiben,	pre	207
4# CIPC,	pre, granular	184
4# Trietazine		119
	L.S.D. 5%	57

1/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 4. Weight Per Topped Carrot Following Pre-Emergence Application of Various Herbicides.

Acre rate of herbicide (AI)		Weight (lbs.) topped carrot 1/
4# CIPC,	pre + granular	.263
10# Zytron,	pre	.246
4# Karsil,	post	.238
4# Trietazine,	pre	.228
8# Dacthal,	pre	.227
2# Amiben,	pre	.224
4# Amiben,	pre	.215
4# Dacthal	pre	.196
Check		.154
	L.S.D. 5%	.053

1/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 5. Rating of Broadleaf Weed Control Following Pre-Emergence Application of Various Herbicides.1/

Acre rate of herbicide (AI)		Means converted to angles	Means reconverted
4# Trietazine,	Pre	1.034	9.8
10# Zytron,	Pre	1.026	9.6
4# Karsil,	Post	1.026	9.6
4# Amiben,	Pre	.894	6.8
4# Dacthal,	Pre	.835	5.8
4# CIPC - Granular,	Pre	.806	5.4
8# Dacthal,	Pre	.760	4.8
2# Amiben,	Pre	.230	.7
Check		.050	.1
	L.S.D. 5%	.141	
	1%	.188	

1/ 1 = no control; 10 = 100% control.

Table 6. Carrot Yield Following Post-Emergence Application of Various Herbicides.

Acre rate of herbicide (AI)		Pounds topped carrots per acre 1/	Rank2/ Number carrots per plot	Rank2/ Weight per carrot
6# Solan,	post	35728	2	4
4# Solan,	post	34858	1	5
6# Dicryl,	post	34162	3	3
4# Dicryl,	post	31900	7	2
3# Dicryl,	post	31842	8	1
6# Karsil,	post	29232	5	8
3# Karsil,	post	29116	6	7
4# Karsil,	post	28710	4	6
Check		18966	9	9
	L.S.D. 5%	5974		

1/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

2/ 1 = highest; 2 = lowest.

Table 7. Plot Yield, Number of Gourds Per Plot, and Weight Per Gourd Following Pre-Emergence Application of Various Herbicides to Golden Delicious Squash.

Acre rate of herbicide (AI)	Yield per plot, lbs. 1/	Weight per gourd, lbs. 2/	Number of gourds per plot	Broadleaf weed control
3# DNBP	130.1	9.3	14.0	10.0
10# Zytron	105.3	8.0	13.0	9.7
6# Amiben, granular	94.1	6.6	14.3	3.7
Check	43.3	3.8	11.3	1.0
L.S.D. 5%	35.9	1.4	NS	
1%	54.3	2.2		

1/ Means within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

2/ 1 = no control; 10 = 100% control.

WEED CONTROL IN SWEET CORN WITH DACTHAL, TRIAZINES, DNBP, AND THIOLCARBAMATES

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

INTRODUCTION

This paper is a report on the effectiveness of the herbicides listed in Table 1 in controlling annual broadleaf weeds in sweet corn. Annual grasses were not present in sufficient amount to permit reliable evaluation of control.

Procedure

Carmel Cross sweet corn was planted June 7, 1960, one to two inches deep in a sandy loam soil. Treatments were replicated five times in randomized blocks of single row treated plots paired with untreated plots. Sprays were applied with one pass of a small plot sprayer, at 40 pounds pressure and 50 gallons per acre volume. Granular materials were applied by hand. All plots were cultivated throughout the season, but during cultivation the soil was not disturbed six inches on either side of the crop row. Corn was harvested at the soft dough stage of maturity.

The principal broadleaf weeds were: Black mustard (*Brassica nigra* Koch.), Red-root pigweed (*Amaranthus retroflexus* L.), and Lambsquarters (*Chenopodium album* L.). Broadleaf weeds averaged 45.7 per square foot in untreated plots. The annual grass present was: Barnyard grass (*Echinochloa crusgalli* Beauv.).

Rainfall data are in Table 2.

Results

A. Planting Applications of Simazine, Trietazine, Atrazine, Diuron, Falone, Dacthal and DNBP Plus Dalapon, Tables 3 and 4.

Planting applications of 2 pounds of Simazine, 2 pounds of Atrazine, and 2, 3, or 4 pounds of Trietazine produced significantly higher yields of sweet corn than planting applications of 0.6 or 1.2 pounds of Diuron, and 4, 6, or 8 pounds of Dacthal and emergence application of 6 pounds of Falone or all combinations of DNBP plus Dalapon, Table 3. Falone and DNBP-Dalapon combinations injured corn moderately to severely.

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Atrazine, Simazine, Trietazine, Diuron, and Falone gave 91.6 percent or higher control of broadleaf weeds, Table 4. Eight pounds of Dacthal gave 66.4 percent, 6 pounds 50.2 percent, and 4 pounds 44.7 percent control of broadleaf weeds. The highest percent broadleaf weed control obtained with DNBP-Dalapon combinations was 73.2 percent.

B. Emergence Application of Various Herbicides, Tables 5 and 6.

Two pounds of Atrazine applied at either planting or at emergence, and emergence application of two or four pounds of Trietazine, 3 pounds of DNBP in combination with 0.6 pounds Diuron, or 2 or 4 pounds of Trietazine produced statistically equal yields of sweet corn, Table 5. Statistically equal yields were produced by 3 pounds DNBP plus 0.6 pounds Diuron, 3 pounds DNBP in combination with 2 or 4 pounds of Trietazine, and 4 or 6 pounds of Dacthal. Four and one-half pounds of DNBP produced statistically lower yields than 3 pounds DNBP plus 0.6 pounds of Diuron.

Statistically equal control of broadleaf weeds was obtained with 2 pounds of Atrazine applied at either planting or at emergence and with emergence applications of 4 pounds Trietazine alone, or 3 pounds DNBP in combination with either 2 or 4 pounds of Trietazine or 0.6 pounds of Diuron. These treatments gave significantly better broadleaf weed control than 4.5 pounds DNBP applied at emergence.

Broadleaf weed control following emergence application of 3 pounds DNBP plus 0.6 pounds of Diuron did not differ significantly from emergence application of either 2 pounds of Trietazine, or 3 pounds DNBP in combination with 4 or 6 pounds of Dacthal. Four or six pounds of Dacthal alone did not give satisfactory broadleaf weed control.

C. Planting Application of Granular Herbicides, Tables 7 and 8.

In a test of granular materials, planting applications of 2 pounds of Atrazine, 2 pounds of Simazine, or 2 or 4 pounds of Trietazine produced significantly higher yields than 6 pounds of Dacthal, Table 7. The difference in yield is a reflection of difference in broadleaf weed control: the triazines gave 97 percent or higher control compared to 33.9 percent control for 6 pounds of Dacthal not worked into the soil and 9.0 percent for 6 pounds of Dacthal worked into the soil, Table 8.

Dacthal worked into the top inch of soil at the time of application gave significantly lower broadleaf weed control than Dacthal not worked in. The activity of Trietazine and Atrazine, however, was not significantly affected by incorporation into the soil, Table 8.

D. <u>Planting Application of Thiolcarbamates and Dichlorobenzonitrile, Tables 9 and 10.</u>

Dichlorobenzonitrile and 4 or 6 pounds of R-2061 (propyl ethyl-n-butylthiolcarbamate) injured Carmel Cross sweet corn to the extent that yields were reduced in spite of excellent weed control, Table 10. Four or six pounds of R-1607 and 4 or 6 pounds of EPTC did not differ significantly in effect on yield, Table 9.

Conclusions

Planting application of Atrazine, Simazine, and Trietazine produced higher yields of Carmel Cross sweet corn than planting application of Diuron or Dacthal and emergence application of Falone or DNBP-Dalapon mixtures. Falone and DNBP-Dalapon treatments resulted in obvious injury to corn plants. Diuron did not produce obvious injury.

Contrasted to planting application of Diuron alone, an emergence application of 0.6 pounds of Diuron plus 3 pounds DNBP per acre did not differ significantly in yield from planting or emergence applications of 2 pounds of Atrazine or emergence application of 2 or 4 pounds of Trietazine.

Depending upon comparative costs of materials, from a production point of view, an emergence application of Diuron-DNBP might have a slight cost advantage over the triazines without reduction either of yield or of weed control. No benefit in 1960 was observed for soil incorporation of either granular Atrazine or granular Trietazine. Working Dacthal, into the top inch of soil, however, reduced percent weed control compared to undisturbed surface application.

Four or six pounds per acre of propyl ethyl-n-butylthiolcarbamate (Stauffer R-2061) and 4 pounds of dichlorobenzonitrile, injured Carmel Cross sweet corn. Four or six pounds of n-propyl-di-n-propylthiolcarbamate (Stauffer R-1607) and 4 or 6 pounds of EPTC did not differ significantly in effect on yield.

Table 1. Herbicides Used in Sweet Corn, 1960.

Designation	Active Ingredient (AI)[1/]
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Dacthal	dimethyl 2,3,5,6-tetrachloroterephthalate
Dalapon	2,2-dichloropropionic acid
Dichlorobenzonitrile (Niagara)	2,4,-dichlorobenzonitrile
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
DNBP	dinitro-o-sec-butylphenol
EPTC	ethyl N, N-di-n-propylthiolcarbamate
Falone	tris-(2,4-dichlorophenoxyethyl) phosphite
R-1607 (Stauffer)	n-propyl-di-n-propylthiolcarbamate
R-2061 (Stauffer)	propyl ethyl-n-butylthiolcarbamate
Simazin	2-chloro-4,6-bis (ethylamino-s-triazine
Trietazine	2-chloro-4-diethylamino-6-ethylamino-s-triazine

1/ AI = active ingredient
WP = wettable powder
GR = granular

Table 2. Rainfall, Monmouth, Maine - June, July, August, 1960.

Date	Inches rainfall	Date	Inches rainfall	Date	Inches rainfall
June 1	.07	July 2	.01	August 5	.13
2	.01	3	.50	7	.16
5	.08	4	.05	8	.55
14	.03	5	.05	10	.08
15	2.05	7	.13	15	.59
16	.02	8	.10	19	.81
18	.10	12	.30	21	.01
22	.02	13	1.19	22	.15
23	.82	17	.10		
24	.55	18	1.50		
25	.02	19	1.90		
		20	.05		
		22	.02		
		23	.06		
		27	.38		
		30	1.40		

Table 3. Yield of Carmel Cross Sweet Corn Following Planting Application of Various Herbicides.

Acre rate of herbicide (AI)		Tons snapped ears per acre	Rank Yield	Rank Weed control Broadleaf
2# Simazine, WP 1/	PL 2/	6.41 3/	1	2
3# Trietazine, WP	PL	5.75	2	3
2# Atrazine, WP	PL	5.53	3	1
4# Trietazine, WP	PL	5.44	4	5
2# Trietazine, WP	PL	5.32	5	7
1# Trietazine, WP	PL	4.54	6	9
1.2# Diuron, WP	PL	4.14	7	4
0.6# Di ron, WP	PL	4.08	8	8
6# Falone,	EM	3.98	9	6
6# Dacthal, WP	PL	3.25	10	14
4# Dacthal, WP	PL	3.17	11	15
8# Dacthal, WP	PL	2.80	12	12
3# DNBP + 2.22# Dalapon	EM	2.73	13	10
3# DNBP + 4.44# Dalapon	EM	2.12	14	11
Check		.68	15	16
3# DNBP + 8.88# Dalapon	EM	.25	16	13
L.S.D. 5%		.99		
1%		1.32		

1/ WP = wettable powder

2/ Corn planted 6 June, 1960.
PL = applied 7 June, 1960; EM applied at emergence 13 June, '60.

3/ Means within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 4. Percent Broadleaf Weed Control Following Planting Application of Various Herbicides.

Acre rate of herbicide (AI)		Means converted to angles	Means % [2/]	Rank
2# Atrazine WP [1/]	PL	88.16	99.9	1
2# Simazine WP	PL	87.39	99.8	2
3# Trietazine WP	PL	86.82	99.7	3
1.2# Diuron WP	PL	86.20	99.6	4
4# Trietazine WP	PL	86.06	99.5	5
6# Falone	EM	81.40	97.8	6
2# Trietazine WP	PL	80.01	97.0	7
0.6# Diuron WP	PL	78.65	96.1	8
1# Trietazine WP	PL	73.17	91.6	9
3# DNBP + 2.22# Dalapon	EM	58.79	73.2	10
3# DNBP + 4.44# Dalapon	EM	55.13	67.3	11
8# Dacthal WP	PL	54.60	66.4	12
3# DNBP + 8.88# Dalapon	EM	48.88	56.8	13
6# Dacthal WP	PL	45.11	50.2	14
4# Dacthal WP	PL	41.94	44.7	15
L.S.D.	5%	10.03		
	1%	13.36		

1/ WP = wettable powder

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 5. Yield of Carmel Cross Sweet Corn Following Emergence Application of Various Herbicides.

Acre rate of herbicide (AI)		Tons snapped ears per acre [2]	Rank: Yield	Rank: Weed control Broadleaf
2# Atrazine WP	PL [1]	6.23	1	1-3
4# Trietazine WP	EM	6.17	2	1-3
2# Atrazine WP	EM	6.14	3	1-3
3# DNBP + 0.6# Diuron,	EM	5.76	4	6
2# Trietazine WP,	EM	5.49	5	7
3# DNBP + 2# Trietazine,WP	EM	5.31	6	5
3# DNBP + 4# Trietazine WP	EM	4.67	7	4
3# DNBP + 6# Dacthal WP	EM	4.59	8	8
3# DNBP + 4# Dacthal WP	EM	4.32	9	9
3# DNBP + 2.22# Dalapon	EM	4.08	10	11
6# Dacthal WP	EM	3.66	11	14
4.5# DNBP	EM	3.57	12	10
4# Dacthal WP	EM	3.43	13	15
3# DNBP + 4.44# Dalapon	EM	2.54	14	12
Check		1.72	15	16
3# DNBP + 8.88# Dalapon	EM	1.06	16	13
L.S.D. 5%		1.32		
1%		1.76		

1/ Corn planted 6 June, 1960.
PL applied 7 June, '69; EM = applied 13 June, 1960.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 6. Percent Broadleaf Weed Control Following Emergence Application of Various Herbicides.

Acre rate of herbicide (AI)		Means converted to angles	Means % [1/]	Rank
2# Atrazine,	PL	90.00	100.00	1-3
2# Atrazine,	EM	90.00	100.00	1-3
4# Trietazine,	EM	90.00	100.00	1-3
3# DNBP + 4# Trietazine,	EM	88.15	99.9	4
3# DNBP + 2# Trietazine,	EM	84.90	99.2	5
3# DNBP + 0.6# Diuron,	EM	79.47	96.7	6
2# Trietazine,	EM	75.20	93.5	7
3# DNBP + 6# Dacthal,	EM	71.00	89.4	8
3# DNBP + 4# Dacthal,	EM	70.66	89.0	9
4.5# DNBP	EM	64.07	80.9	10
3# DNBP + 2.22# Dalapon,	EM	59.30	73.9	11
3# DNBP + 4.44# Dalapon,	EM	56.28	69.2	12
3# DNBP + 8.88# Dalapon,	EM	51.08	60.5	13
6# Dacthal	EM	50.22	59.1	14
4# Dacthal	EM	41.98	49.7	15
L.S.D.	5%	11.59		
	1%	15.42		

1/ Means included within brackets are not significantly different at 5% level (Duncan's Multiple Range Test).

Table 7. Yield of Carmel Cross Sweet Corn and Broadleaf Weed Control Following Application of Various Granular Herbicides.

Acre rate of herbicides (AI)	Tons snapped ears per acre [2]	Rank Weed control Broadleaf
2# Atrazine GR worked in [1]	5.10	3
4# Trietazine GR not worked in	4.99	2
2# Atrazine GR not worked in	4.52	1
2# Simazine GR not worked in	4.17	5
4# Trietazine GR worked in	3.77	4
6# Dacthal GR not worked in	1.15	6
Check	1.13	8
6# Dacthal GR worked in	.54	7
L.S.D. 5%	1.08	
1%	1.45	

1/ Corn planted 6 June, 1960. Herbicides applied 7 June, '60. Herbicides raked to top inch of soil.

2/ Means included within brackets not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 8. Broadleaf Weed Control Following Application of Various Granular Herbicides.

Acre rate of herbicides	Means converted to angles	Means % [2]	Rank
2# Atrazine not worked in [1]	88.00	99.9	1
4# Trietazine not worked in	86.48	99.6	2
2# Atrazine worked in	86.42	99.6	3
4# Trietazine worked in	81.92	98.0	4
2# Simazine not worked in	81.28	97.7	5
6# Dacthal not worked in	17.48	33.9	6
6# Dacthal worked in	17.48	9.0	7
L.S.D. 5%	11.61		
1%	15.63		

1/ Herbicides raked into top inch of soil.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 9. Yield of Carmel Cross Sweet Corn Following Application of Various Thiolcarbamates and Dichlorobenzonitrile.

Acre rate of herbicide 1/	Tons snapped ears per acre 2/	Rank: Yield	Rank: Weed control Broadleaf
6# R-1607 (n propyl-di-n-propylthiolcarbamate	3.36	1	4
4# EPTC	2.44	2	5
4# R-1607	2.04	3	3
6# EPTC	1.94	4	7
4# Dichlorobenzonitrile, GR	1.53	5	1
6# R-2061 (propyl ethyl-n-butylthiolcarbamate	1.49	6	2
4# R-2061	.68	7	6
Check	.58	8	8
L.S.D. 5%	1.48		

1/ Applied at planting. All herbicides were worked into the top inch of soil.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 10. Broadleaf Weed Control Following Application of Various Thiolcarbamates and Dichlorobenzonitrile

Acre rate of herbicide 1/		Means (%) converted to angles 2/	Means %	Rank
4# Dichlorobenzonitrile	PL	90.00	100.0	1
6# R-2061	PL	81.01	97.6	2
4# R-1607	PL	61.74	77.6	3
6# R-1607	PL	60.82	76.2	4
4# EPTC	PL	47.48	54.3	5
4# R-2061	PL	38.20	38.3	6
6# EPTC	PL	37.01	36.2	7
L.S.D. 5%		17.42		
1%		23.76		

1/ Applied at planting; all herbicides were worked into the top inch of soil.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

ANNUAL WEED CONTROL IN POTATOES WITH DNBP, DALAPON, DACTHAL, TRIETAZINE, AND OTHER HERBICIDES

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

INTRODUCTION

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

Procedure

Katahdin potatoes were planted in a sandy loam soil the week of May 30, 1960. Seed pieces were spaced 12 inches in rows 42 inches apart. Treatments were replicated six times in randomized blocks of single-row plots paired with untreated plots. Sprays 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 24 inches wide at the base, ten inches high, and six inches wide at the top.

The principal broadleaf weeds were: Wild Rutabaga (*Brassica rapa* L.); Red-root pigweed (*Amaranthus retroflexus* L.); and Lambsquarters (*Chenopodium album* L.). The annual grasses, Barnyard grass (*Echinochloa crusgalli* L.) and Foxtail (*Setaria viridis* L.), were not present in sufficient quantity to permit accurate evaluation of control. Weed counts were made 10 weeks after planting.

Results

A. Comparisons of DNBP-DALAPON Mixtures with DACTHAL-TRIETAZINE Mixtures

Data obtained in 1959 (1) indicated that mixtures of Dacthal and Trietazine might result in better total annual weed control than either herbicide alone, since Dacthal "where Brassica species are present, need reinforcement with a predominantly broadleaf herbicide" and "Trietazine needs reinforcement with a graminicide." Data obtained in 1959 further indicated that mixtures of Dacthal and Trietazine might result in a longer period of residual weed control than the currently recommended DNBP-DALAPON mixture.

Data in Tables 2 and 3 show that none of the other treatments produced statistically higher yields than the standard treatment of 3 pounds DNBP plus 2.22 pounds Dalapon per acre.

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Four, six, and eight pounds of Dacthal per acre (Tables 2 and 4) are insufficient for adequate broadleaf weed control. Twelve pounds of Dacthal did not differ significantly in effect from mixtures of 6 pounds of Dacthal plus 2 pounds of Trietazine, 8 pounds of Dacthal plus 3 pounds DNBP, or 3 pounds DNBP plus 2.22 pounds Dalapon. Dacthal even at the 12 pound rate did not completely control smart weed (Polygonum spp.) or mustards (Brassica spp.). Eight pounds of Dacthal in the block reported in Tables 3 and 5 gave satisfactory broadleaf weed control because fewer mustards and smart weeds were present than in the block reported in Tables 2 and 4.

Data in Table 5 indicate the extent to which Trietazine-Dacthal mixtures may increase broadleaf weed control over that obtained from Dacthal alone:

Herbicide	Percent Control
8 pounds Dacthal	77.8
8 pounds Dacthal plus 2 pounds Trietazine	92.4
4 pounds Dacthal plus 4 pounds Trietazine	92.8
6 pounds Dacthal plus 2 pounds Trietazine	80.9
6 pounds Dacthal plus 4 pounds Trietazine	89.6

The effect of Trietazine alone on weed control is shown from tests in other crops. Percent weed control for all crops has been averaged to obtain the following data:

Herbicide and rate/acre	Percent weed control		Yield: Average rank for all blocks of tolerant crops. 1 = lightest yield; 10 = lowest yield
	Broadleaf	Annual grass	
8# Dacthal	68.8	62.7	7.7
6# Dacthal	58.3	34.0	6.0
4# Dacthal	44.4	57.9	6.3
1# Trietazine	91.6	35.8	6.0
2# Trietazine	92.3	60.4	5.0
6# Dacthal + 2# Trietazine	89.2	67.5	3.5
8# Dacthal + 2# Trietazine	92.4	74.2	5.0
3# DNBP + 2.22# Dalapon	78.6	80.6	4.7

The increase in annual grass control for the mixtures compared to Trietazine alone, and the increase in broadleaf weed control for the mixtures compared to Dacthal alone are presumably significant. Whether or not the increase in yield is significant for the mixtures over Trietazine alone is dubious.

The effect of rainfall on the comparative performance of Dacthal (water solubility 0.5 ppm.) and Trietazine (water solubility 20 ppm.) is shown in weed control data for 1959 and 1960:

Herbicide	Percent Weed Control 1959 Broadleaf weeds	1959 Annual grasses	1960 Broadleaf weeds	1960 Annual grasses
6 pounds Dacthal	85.4	70.3	58.3	34.0
8 pounds Dacthal	84.2	89.4	68.8	62.7
1 pound Trietazine	40.4	13.5	91.6	35.8
2 pounds Trietazine	77.9	18.0	92.3	60.4

In 1959, 1.80 inches of rain fell during the first ten days after treatments had been applied; in 1960, .12 inches fell during the first ten days. Total rainfall in 1959 for the first twenty days following application of treatment was 5.17 inches, in 1960 2.32 inches.

The poor weed control obtained in 1960 tests with Dacthal apparently resulted from insufficient rainfall. The poor weed control in 1959 with 1 and 2 pounds Trietazine can be attributed to high rainfall reducing effectiveness of the relatively low rates of application by excessive leaching. The 4 pound rate of Trietazine in 1959 gave 97.8 percent control of broadleaf weeds and 24.7 percent control of annual grasses.

B. Comparisons of Several Rates of DNBP-DALAPON Mixtures with Cacodylic Acid, Falone, and Dichlorobenzonitrile

None of the treatments produced yields significantly higher than 3 pounds DNBP plus 2.22 pounds of Dalapon, although 3 pounds DNBP plus 4.44 pounds Dalapon, and 8 pounds of Falone gave numerically higher yields, Table 6. Eight pounds of cacodylic acid did not satisfactorily control broadleaf weeds, Table 7. Dichlorobenzonitrile at both 2 and 4 pound rates inhibited sprouting and reduced the stand of potatoes.

C. Comparison of a DNBP-DALAPON Mixture with Thiolcarbamates

None of the thiolcarbamates tested produced yields of Katahdin potatoes significantly higher than 3 pounds DNBP plus 2.22 pounds Dalapon, Table 8. Three pounds DNBP plus 2.22 pounds Dalapon, and 6 pounds R-1607 (n-propyl-di-n-propylthiolcarbamate) produced significantly higher yields than 6 pounds of R-2061 (propyl-ethyl-n-butyl thiolcarbamate). Six pounds EPTC did not differ significantly in effect on yield for either the DNBP-Dalapon mixture or for R-1607.

The DNBP-Dalapon mixture gave significantly better broadleaf weed control than R-1607 or R-2061, but did not differ significantly from EPTC.

D. Comparison of Post-Emergence Applications of Solan and Falone

Three and six pounds of Solan, and 6 pounds of Falone applied post-emergence, did not significantly affect the yield of Katahdin potatoes, Table 9. Six pounds of Solan gave significantly better broadleaf weed control than either 3 pounds of Solan or 6 pounds of Falone. The principal weed, Lambsquarters, was six inches tall at the time of spraying.

Conclusions

Under the rainfall conditions prevailing in 1960 in blocks in which annual grasses were not present in competitively significant amount, none of the candidate herbicides in pre-emergence tests produced significantly higher yields of Katahdin potatoes than the standard treatment of 3 pounds DNBP plus 2.22 pounds of Dalapon per acre.

Treatments producing yields statistically equal to those of standard were:

8 pounds Dacthal
12 pounds Dacthal
8 pounds Dacthal plus 3 pounds DNBP
6 pounds Dacthal plus 2 or 4 pounds Trietazine
4 pounds Dacthal plus 4 pounds Trietazine
8 pounds Dacthal plus 2 or 4 pounds Trietazine
8 pounds Falone
6 pounds EPTC
6 pounds n-propyl-di-n-propylthiolcarbamate

In 1960 the combination treatment of Dacthal plus Trietazine was not significantly better than Trietazine alone. By combining data for 1959 and 1960, however, it can be hypothesized, that a mixture of Dacthal and Trietazine compared to either material alone, might insure consistently satisfactory performance in spite of rather wide seasonal variation in rainfall. In 1960 as in 1959, Dacthal even at the rate of 12 pounds per acre rate did not completely control Brassica species. Solan at a 6 pound per acre rate appeared to have promise for post-emergence application.

Literature Cited

1. Trevett, M.F., Murphy, H.J., Gardner, William. Control of Annual Weeds in Potatoes. Proceedings of Northeast Weed Control Conference. p. 207. 1960.

Table 1. Herbicides Used in Potatoes.

Designation	Active Ingredient
Cacodylic Acid	Dimethylarsinic acid
Dacthal	Dimethyl 2,3,5,6-tetrachloroterephthalate
Dalapon	2,2-dichloropropionic acid
Dichlorobenzonitrile (Niagara 5996)	2,6-dichlorobenzonitrile
DNBP	dinitro-o-sec-butylphenol
EPTC	ethyl n,n-di-n-propylthiolcarbamate
Falone	tris-(2,4-dichlorophenoxyethyl) phosphite
R-1607 (Stauffer)	n-propyl-di-n-propylthiolcarbamate
R-2061 (Stauffer)	propyl ethyl-n-butylthiolcarbamate
Solan	n-(3-chloro-4-methylphenyl)-2-methyl-pentanamide
Trietazine	2-chloro-4-diethylamino-6-ethylamino-s-triazine

Table 2. Comparisons Between Rates of Dacthal and Dacthal-Trietazine, and DNBP-Dalapon Mixtures.

Acre rate of herbicide		Bushels per acre [2]	Rank: Yield	Rank: Weed control Broadleaf
6# Dacthal WP + 2# Trietazine	PL[1]	531	1	1
12# Dacthal WP	PL	507	2	4
8# Dacthal WP + 3# DNBP	EM[1]	496	3	2
3# DNBP + 2.22# Dalapon	EM	469	4	3
8# Dacthal WP	EM	446	5	6
8# Dacthal WP	PL	424	6	7
6# Dacthal WP	PL	397	7	5
4# Dacthal WP	PL	367	8	8
Check		166	9	9
L.S.D. 5%		94		
1%		126		

1/ PL = herbicide applied at planting; EM = herbicides applied at emergence.
Planted 31 May, '60; PL applied 1 June, '60; EM applied 14 June, '60.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 3. Comparisons Between Various Dacthal-Trietazine Mixtures and a DNBP-Dalapon Mixture.

Acre rate of herbicide		Bushels per acre [2]	Rank Yield	Rank Weed control Broadleaf
3# DNBP + 2.22# Dalapon,	EM[1]	416	1	1
4# Dacthal WP + 4# Trietazine,	PL[1]	413	2	2
8# Dacthal WP + 4# Trietazine,	PL	398	3	5
6# Dacthal WP + 4# Trietazine,	PL	396	4	4
8# Dacthal WP + 2# Trietazine,	PL	393	5	3
6# Dacthal WP + 2# Trietazine,	PL	356	6	6
8# Dacthal WP	PL	263	7	7
Check		164	8	8
L.S.D. 5%		82		
1%		109		

1/ PL = applied at planting; EM = applied at emergence
Planted 1 June, '60; PL applied 2 June, '60; EM applied 14 June, '60.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 4. Annual Broadleaf Weed Control Following Treatment with Rates of Dacthal, and Dacthal-Trietazine and DNBP-Dalapon Mixtures.

Acre rate of herbicide	[1]	Means converted to angles [2]	Means %	Rank
6# Dacthal WP + 2# Trietazine,	PL	80.65	97.4	1
8# Dacthal WP + 3# DNBP	EM	77.06	95.0	2
3# DNBP + 2.22# Dalapon,	EM	74.11	92.5	3
12# Dacthal WP,	PL	67.35	85.2	4
6# Dacthal WP,	PL	54.14	65.7	5
8# Dacthal WP,	EM	52.79	63.4	6
8# Dacthal WP,	PL	51.66	61.5	7
4# Dacthal WP,	PL	38.65	39.0	8
L.S.D. 5%		15.53		
1%		20.74		

1/ EM = applied at emergence; PL = applied at planting.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test). There were 56.5 broadleaf weeds per square foot in check plots.

Table 5. Annual Broadleaf Weed Control Following Treatment with Various Dacthal-Trietazine Mixtures and a DNBP-Dalapon Mixture.

Acre rate of herbicide		% Broadleaf weed control	Rank
		1/	
3# DNBP + 2.22# Dalapon,	EM	94.9	1
4# Dacthal WP + 4# Trietazine,	PL	92.8	2
8# Dacthal WP + 2# Trietazine,	PL	92.4	3
6# Dacthal WP + 4# Trietazine,	PL	89.6	4
8# Dacthal WP + 4# Trietazine,	PL	88.6	5
6# Dacthal WP + 2# Trietazine,	PL	80.9	6
8# Dacthal WP,	PL	77.8	7
L.S.D. 10%		10.3	

1/ EM = applied at emergence; PL = applied at planting.

2/ There was 65.9 broadleaf weeds per square foot in check plots.

Table 6. Yield of Katahdin Potatoes Following Emergence Application of DNBP-Dalapon Mixtures, Falone, Cacodylic Acid, and Dichlorobenzonitrile.

Acre rate of herbicides		Bushels per acre	Rank: Yield	Rank: Weed control Broadleaf
	1/	2/		
3# DNBP + 4.44# Dalapon,	EM	357	1	5
8# Falone	EM	351	2	1
3# DNBP + 2.22# Dalapon,	EM	296	3	4
3# DNBP + 8.88# Dalapon,	EM	260	4	3
Check		96	5	8
8# Cacodylic Acid	EM	92	6	6
2# Dichlorobenzonitrile	EM	83	7	7
4# Dichlorobenzonitrile	EM	71	8	2
L.S.D. 5%		64		
1%		86		

1/ EM = applied emergence
Planted 1 June, '60; EM applied 14 June, 1960.

2/ Means included within brackets are not significantly different at the 5% level. (Duncan's Multiple Range Test).

Table 7. Broadleaf Weed Control Following Pre-Emergence Application of DNBP-Dalapon Mixtures, Falone, Cacodylic Acid, and Dichlorobenzonitrile.

Acre rate of herbicide		% Broadleaf weed control 2/	Rank
8# Falone,	EM	88.6	1
4# Dichlorobenzonitrile		77.3	2
3# DNBP + 8.88# Dalapon,	EM	69.0	3
3# DNBP + 2.22# Dalapon,	EM	58.6	4
3# DNBP + 4.44# Dalapon,	EM	57.4	5
8# Cacodylic Acid,	EM	25.7	6
2# Dichlorobenzonitrile,	PL, Incorporated	24.1	7
	L.S.D. 5%	23.6	
	1%	31.7	

1/ EM = applied at emergence 14 June, '60
PL = applied at planting 1 June, '60.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 8. Yield of Katahdin Potatoes and Broadleaf Weed Control Following Planting Application of a DNBP-Dalapon Mixture, and Thiolcarbamates.

Acre rate of herbicide		Bushels per acre 2/	% Broadleaf weed control
3# DNBP + 2.22# Dalapon,	EM 1/	312	80.3
6# R-1607 (n-propylthiolcarbamate)	PL 1/	282	61.1
6# EPTC	PL	222	66.4
6# R-2061 (propyl ethyl-n-butyl-thiolcarbamate)		187	44.0
Check		117	0
	L.S.D. 5%	91	17.4
	1%	125	

1/ EM = applied herbicide pre-emergence; PL = applied herbicide at planting.

Planted June 1, '60.
EM applied 14 June, '60. PL applied 2 June, '60.

2/ Means included within brackets are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 9. Effect of Post-Emergence Application of Solan and Falone on Yields of Katahdin Potatoes.

Acre rate of herbicide	Bushels per acre	Rating[2] broadleaf weed control
6# Solan[1]	491	8.50
3# Solan	437	3.75
Check	416	0
6# Falone	406	2.75
L.S.D. 5%	NS	4.3

1/ Planted 10 June, '60. Herbicides applied post-emergence 21 July, '60.

2/ 10 = maximum weed control; 0 = no weed control.

Chemical Weed Control in Sweet Corn

Charles J. Noll[1]

Sweet corn has been weeded on a commercial basis for many years with the chemicals, 2,4-D or water soluble dinitro. Under most conditions either of these chemicals do a satisfactory job although some times weeds are not controlled or crops injured. More foolproof chemicals such as Atrazine and Simazine have lately been used in the weeding of corn. The experiment reported in this paper is a continuation of work started years ago.

Procedure

The variety NK 199 was seeded May 27, 1960. Pre-emergence treatments were applied 5 days after seeding and emergence treatments 10 days after seeding. Individual plots were 36 feet long and 3 feet wide. Treatments were randomized in each of 8 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. The growing season was cooler than average and rainfall below normal. An estimate of weed control was made August 10 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Corn harvest was completed August 29.

Results

The results are presented in Table I. All chemicals gave highly significant increases in weed control as compared to the untreated check. The best weed control was in plots treated with Simazin, either liquid or granular, Atrazine, Diuron, Neburon, Benzac, or the higher rates of Fenac and Amiben.

Stand was significantly reduced by only one chemical Niagara 5996 applied at a rate of 4 lbs. per acre.

Yields as measured by number and weight of marketable ears were with one exception not reduced by the chemicals applied. The chemical Benzac 1281 did greatly reduce the yield. The table shows that some rates of a number of chemicals did significantly increase the yield of corn.

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Conclusion

There are quite a number of chemicals that looks promising for the weeding of sweet corn in addition to the chemicals now recommended. Granular Simazine was equal to liquid Simazin. Atrazine applied at emergence gave weed control and yield equal to Atrazine applied pre-emergence. Diruon and Neburon gave good weed control and yield. Taking into consideration the cost of the chemicals other chemicals included in the experiment are worthy of consideration in the weeding of sweet corn.

Table I. Weed control plant stand and number and weight of marketable ears of corn under chemical herbicide treatment.

Chemical	Active Rate /A lbs.	When Applied Days from Seeding	AVERAGE PER PLOT Weed* Control (1-10)	Stand of Plants	No. of Mkt. Ears	Wt. of Mkt. Ears lbs.
Nothing	--	--	7.0	55	40	21.9
Simazine	2	5	1.2	53	43	25.3
"	3	5	1.0	55	46	25.5
Atrazine	2	5	1.8	54	44	25.7
"	3	5	1.5	55	46	25.4
Dacthal 893	4	5	2.3	54	41	22.6
" "	6	5	3.2	55	41	23.3
Niagara 5996	2	5	5.5	54	38	20.3
" "	4	5	3.2	45	35	20.9
Fenac	2	5	3.0	56	44	22.8
"	4	5	1.8	54	36	19.5
Amiben	4	5	2.5	52	36	19.6
"	6	5	2.0	55	37	19.1
Neburon	3	12	2.2	54	47	26.2
"	$4\frac{1}{2}$	12	1.2	52	44	25.3
Benzac 1281	8	5	1.0	52	7	2.3
" "	12	5	1.0	51	2	.8
CDAA-T (Randox T)	6	5	3.0	56	46	26.0
" "	9	5	3.8	56	46	26.9
CDAA (Randox)	6	5	4.0	56	49	26.4
" "	9	5	2.3	55	46	26.9
Simazine 4G	2	5	1.0	56	49	26.2
" "	4	5	1.0	55	49	27.7
Atrazine (G30027)	2	10	1.8	55	45	25.4
" "	3	10	1.5	55	48	27.5
2,4-D Granular 10%	1	5	2.5	56	46	26.9
" "	2	5	2.3	52	40	23.8
Diuron	2	10	1.0	52	47	27.2
"	3	10	1.2	53	43	24.1
DNBP (Premerge)	3	10	3.0	54	41	24.0
" "	$4\frac{1}{2}$	10	2.7	54	48	27.4
2,4-D (Amine)	$\frac{1}{2}$	10	4.2	53	43	25.0
" "	1	10	3.0	55	44	24.5
Least Significant Difference 5%			1.2	4	7	4.7
" " " 1%			1.6	5	9	6.2

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

SOME RESEARCH AND WEED CONTROL METHODS WITH ASPARAGUS[1]

W. H. Lachman

The study of weed problems in asparagus beds is quite varied in nature and scope since many different weeds invade all asparagus plantations. These may vary from grasses to broad-leafed sorts and from annuals, biennials to perennial types. Often quack grass (Agropyron repens) is the invader along with other insidious pests such as milkweed (Asclepias syriaca), horsetail (Equisetum arvense) and bindweed (Convolvulvus arvensis) not to mention young asparagus seedlings self-sown by the crop itself.

Weed control in asparagus is a problem which has been studied at the Massachusetts Station for many years (4,5). The project is still in progress and it is the purpose of this paper to present the results obtained during the season of 1960.

Materials and Methods

Twelve treatments, involving four chemicals were applied to plots of Waltham Washington asparagus in a randomized block arrangement; these treatments were replicated four times. The plots consisted of single 35-foot rows of asparagus planted four feet apart. A 10-10-10 fertilizer was broadcast at the rate of 1000 pounds per acre and the bed was disced shallowly on May 3. The soil was a Scarborough very fine sandy loam and although of somewhat variable type and depth it was moderately fertile.

The following chemicals with their respective per acre rates (active ingredients) were applied to the plots on May 5: 1.60, 2.40 and 3.20 pounds of monuron; 2.50, 3.75 and 5.00 pounds of Atrazine; 2.00, 4.00 and 6.00 pounds of EPTC and 3.75 and 5.00 pounds of Simazine. All the chemicals were diluted with water and applied at the rate of 50 gallons per acre. The sprays were applied with a Brown Open-Hed No. 4 hand pressure sprayer fitted with a No. 8004 Spraying Systems fan-type nozzle. Plots where EPTC was applied were cultivated immediately to mix the herbicide with the soil; none of the other plots were treated in this manner.

Frequent rains throughout the growing period maintained adequate soil moisture and promoted an abundant weed population which consisted of redroot pigweed (Amaranthus retroflexus), crabgrass (Digitaria sanguinalis), galinsoga (Galinsoga ciliata), chickweed (Stellaria media), purslane (Portulaca oleracea), lamb's quarters (Chenopodium album) and some asparagus seedlings. Much the greater proportion of the population, however, was represented by crabgrass and pigweed. The plots were not cultivated until after the end of the cutting season on July 6.

[1] Contribution No. 1284 of the Massachusetts Agricultural Experiment Station, College of Agriculture, University of Massachusetts, Amherst, Massachusetts.

TABLE I. EFFECT OF HERBICIDES ON WEED GROWTH AT MID-JUNE CUTTING PERIOD

Herbicide	Rate Active Lbs./A.	Weed Control[1/] 1-Poor to 9-Excellent 6/9/60	Weed Index[2/] 6/9/60	Ranked Weed Control[3/] 6/13/60	Predom. Species G = Grass B = Broadleaf 6/9/60
Simazine	5.00	9.0	.02	1.50[4/]	O
Atrazine	5.00	8.5	.20	1.02	B
Simazine	3.75	8.8	.00	.89	O
Atrazine	3.75	8.0	.83	.28	G
Monuron	3.20	8.0	.28	.21	G
EPTC	6.00	7.0	1.56	.12	B
Monuron	2.40	8.0	.61	.06	G
Atrazine	2.50	7.0	3.28	- .32	G
EPTC	4.00	6.5	3.71	- .52	B
Monuron	1.60	6.3	5.43	- .66	G
EPTC	2.00	4.5	8.21	-1.12	B/G
Check	--	1.0	18.75	-1.63	B/G

1/ 1 = normal growth; 7 = commercial control; 9 = complete kill.

2/ Percent weed cover x height (cms.):100 = Weed Index. Seed Lit. Cit. (6).

3/ Expressed as "Rankits". See Lit. Cit. (3,7).

4/ Means included in brackets are not significantly different at the 5% level (Duncan's) Multiple Range Test. See Lit. Cit. (2).

TABLE II. EFFECT OF HERBICIDES ON WEED GROWTH AND YIELD OF ASPARAGUS AT END OF HARVEST PERIOD

Herbicide	Rate Active Lbs./A.	Weed Control[1/] 1-Poor to 9-Excellent 7/1/60	Weed Index[2/] 7/1/60	Weed Control[3/] 7/5/60	Predom. Species G = Grass B = Broadleaf 7/5/60	Yield Market-able-Lbs.
Simazine	5.00	8.3	1.34	1.63[4/]	G	12.8
Simazine	3.75	7.8	2.46	.89	G	14.0
Atrazine	5.00	7.3	9.49	.59	G	12.9
Monuron	3.20	5.5	14.15	.31	G	13.2
Eptam	6.00	3.5	37.59	.18	B/G	12.9
Atrazine	3.75	4.5	18.85	.16	G	12.4
Eptam	4.00	3.5	41.35	.08	B/G	13.5
Monuron	2.40	5.0	19.83	- .17	G	11.9
Atrazine	2.50	2.8	37.82	- .44	G	10.4
Eptam	2.00	2.0	50.14	- .71	B/G	11.6
Monuron	1.60	2.0	41.75	- .89	G	11.5
Check	--	1.0	62.25	-1.63	B/G	11.4
						N.S.

1/ 1 = normal growth; 7 = commercial control; 9 = complete kill.

2/ Percent weed cover x height (cms.):100 = Weed Index. See Lit. Cit. (6).

3/ Expressed as "Rankits". See Lit. Cit. (3,7).

4/ Means included in brackets are not significantly different at the 5% level (Duncan's Multiple Range Test). See Lit. Cit. (2).

Figure 1. WEED CONTROL DURING THE HARVEST PERIOD AS RELATED TO VARIOUS AMOUNTS OF HERBICIDES IN A SINGLE PRE-EMERGENCE APPLICATION

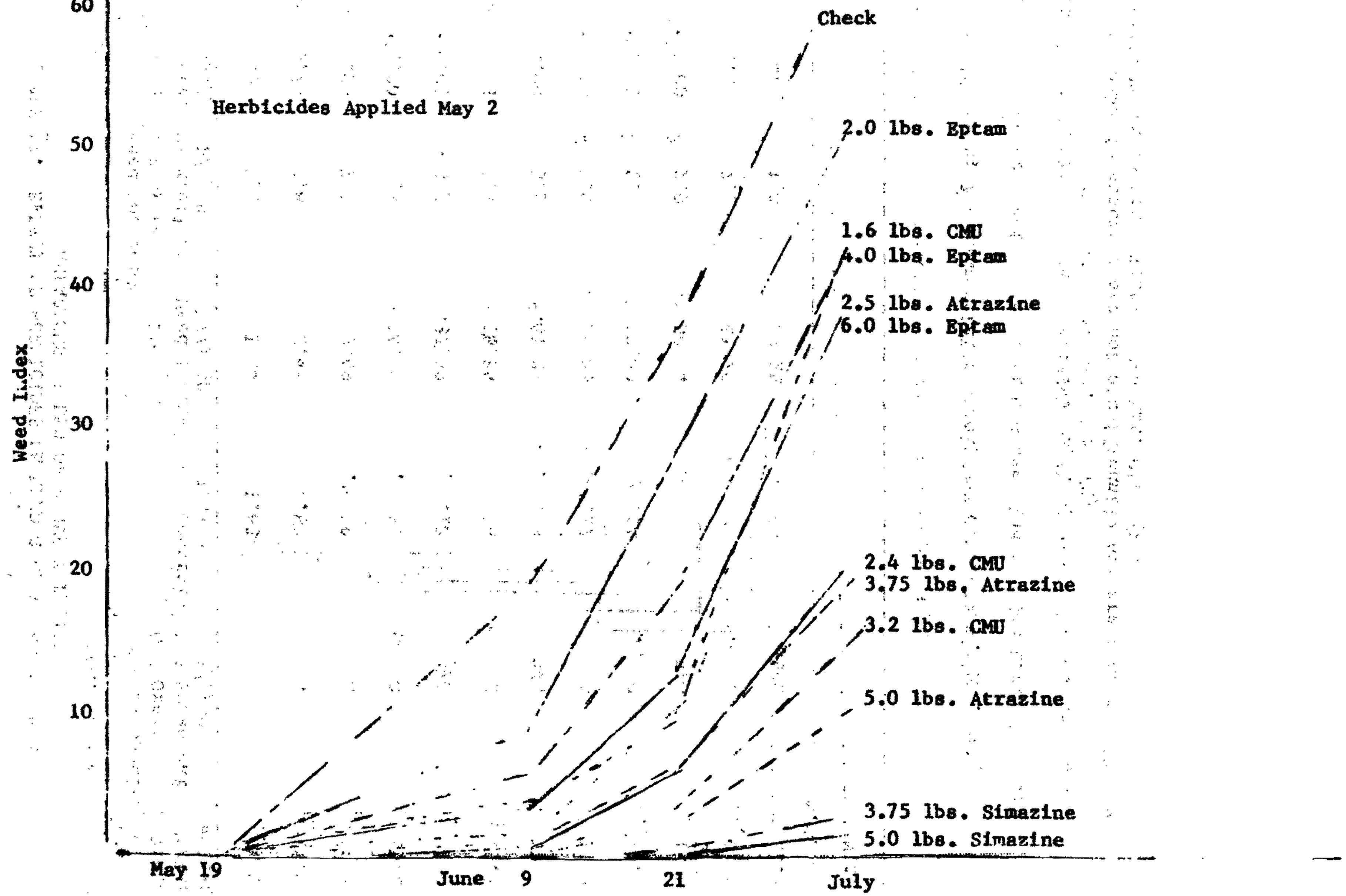
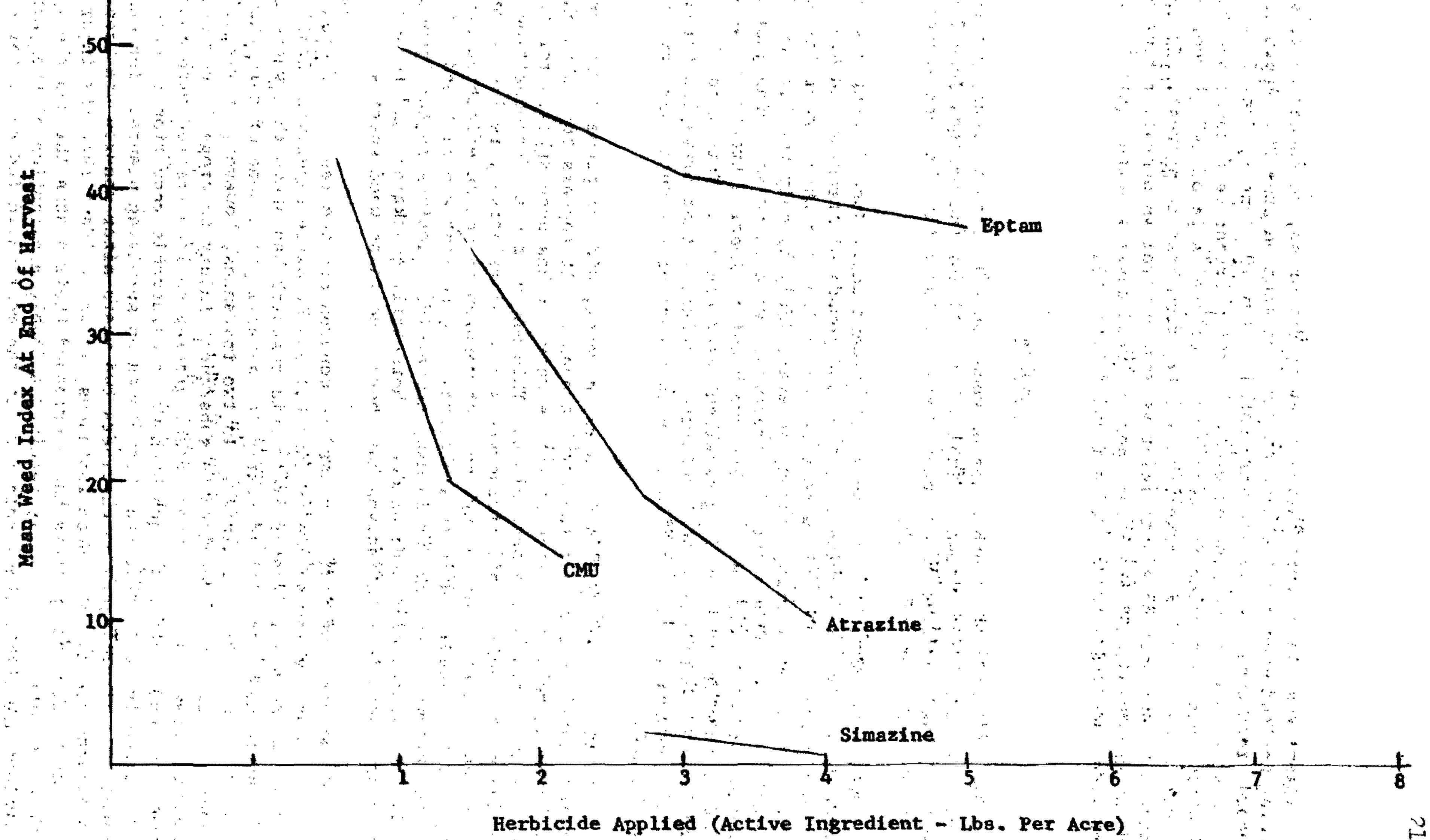


FIGURE 2. WEED CONTROL INDICES AT THE END OF THE HARVEST PERIOD WITH VARIOUS QUANTITIES OF HERBICIDES



Asparagus spears were harvested every day or so, dependent on growth, during May and June and the last cutting was made on June 29. Appropriate records regarding weed growth were noted on May 19, June 9, June 21 and July 1. Notes were made on the kind of weeds present, percent weed cover and their height; plots were rated for weed control on the basis of 1-9 (1 Poor - 9 Excellent) and they were also ranked 1-12, from best to poorest. To compare methods further for assessing relative weed control an overall rating or "weed index" was computed as follows: percent weed cover x height (cms.): 100 = weed index as suggested by Medcalf and deVita (5).

Results

The effect of the herbicides on weed control, weed indices, predominant species and yield are shown in Tables I and II for the periods June 9 and July 1. The resulting "weed index" data for the entire harvest season are plotted in Figures I and II.

Excellent weed control was still evident until June 9 among most of the treatments. At this period only the 2.50 pounds of Atrazine and 4.00 and 6.00 pound applications of EPTC were rated as giving less than commercial control. By the end of the cutting season, however, (July 1) only the 3.75 and 5.00 Simazine and 5.00 pound Atrazine treatments were rated as giving just commercial control or better (Table II). The two heavier Simazine treatments were particularly noteworthy in providing excellent weed control. This might be expected in the light of the optimum soil moisture conditions that prevailed throughout the cutting season and by the relative persistence or residual capacity of Simazine in the soil.

Monuron at 3.20 pounds per acre, however, did not prevent weed growth satisfactorily throughout the cutting season. It appears that this chemical is becoming relatively less effective where it has been applied for five successive years to the same plots. This may be due to decomposition from a build-up of specific soil microorganisms or of relatively resistant weed species. Crabgrass competes well enough so that monuron is not an effective treatment against this weed. Where this chemical is used most annual broadleafed weeds do not become a problem but in many commercial plantings in the Connecticut Valley plantain, milkweed, bindweed, horsetail, quackgrass and in some cases asparagus seedlings themselves have become dominant weed species.

Of special interest in regard to monuron are the results of bioassay tests conducted at the Massachusetts (unpub.) and Delaware Experiment Stations (1). Using oats as the indicator plant this research has shown that where 2-4 pounds of monuron had been applied yearly for several years none of this chemical persisted in the soil over winter. In two instances, however, it was evident that monuron applications resulted in subsequent injury to crops in commercial plantings in Massachusetts. In one case, growing on land treated with monuron the previous year, Butternut squash showed considerable reduction in stand and growth with extensive chlorotic areas developed on surviving plants. The other case, involved similar injury to cucumbers two years after monuron had been applied to asparagus. In both these instances, it was evident that the injury occurred in areas where the sprayers had overlapped their swaths through the field and thus the soil had apparently received a double application of the herbicide. This may indicate that perhaps oats are not the most valid indicator for the presence of monuron in soil.

With respect to asparagus, however, it is interesting to note that none of the herbicides have affected yields significantly (Table II) and Rahn has reported that asparagus showed no visible symptoms of plant injury after eighteen pounds per acre of monuron had been applied annually for three years (8).

It is especially convenient and relatively easy to rate the results of weed control on a 1-9 basis but the means derived from this process should not, strictly speaking, be subjected to variance analysis for these statistics are not valid samples drawn from a normal curve. To serve convenience, therefore, such a statistic may be used to indicate relative weed control only and not to determine significance among means.

The "weed index" is expressed as a percentage and with this type of statistic the figures must first be converted to angles (Angle = Arcsine $\sqrt{\text{Percentage}}$) before it is permissable to subject the data to variance analysis. Where the individual plots are ranked with respect to one another they may be subjected to variance analysis after converting to "Rankits" (3,4).

It will be noted that Duncan's Multiple Range Test was used to determine significance among the means where plots were ranked and converted to "Rankits". Statisticians claim that the L.S.D. is often incorrectly applied to all differences among 3 or more means, the result being that too many of the differences are adjudged significant. The L.S.D. gives correct tests only if a = 2(9). Here Duncan's Multiple Range Test allows for all possible comparisons among means without restriction except that they must be arranged in descending order in the table.

While data presented in tabular form is certainly invaluable and only such proper material is subject to variance analysis it often behooves us to present results in more graphic form. The "weed index" data becomes especially enlightening in Figures I and II. Such presentation may help to orient our thinking and add credence to our statistics per se. In Figure I, more particularly, a quick inspection reveals the relative weed growth condition at any given time during the harvest season and indicates cumulative indices.

Summary

Under the conditions of these tests with adequate soil moisture 3.75 to 5.00 pounds of Simazine resulted in weed control superior to that obtained with Atrazine, monuron and EPTC.

Various methods of measuring and expressing weed growth have been presented among which were: rating 1-9, "weed indices", ranking, and notation of dominant weed species.

It has been emphasized that it is imperative to ascertain those statistics that are true samples from a normal curve before making a variance analysis.

The use of LSD is restricted to those cases where a = 2. The use of Duncan's Multiple Range Test has been illustrated to present a method where all possible comparisons among means is permissable.

Finally, it has been emphasized that graphic summaries are especially valuable in supplementing data presented in tabular form.

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WEED CONTROL IN CERTAIN VEGETABLE CROPS - 1960[1]

W. H. Lachman and H. F. Vernell[2]

This paper reports the results obtained during 1960 from field-screening certain recently developed chemicals with weed killing potentials. The plots in all of these tests were located on a fertile Scarborough very fine, sandy loam. While the land is well drained, its high water holding capacity coupled with ample rainfall seemed to provide conditions that were ideal for killing weeds with chemicals in 1960.

Carrots

Plots were well prepared and seeded to Waltham Hicolor carrots on May 4, 1960. The weed killers used with their respective rates of application are listed in Table I.

All treatments were replicated three times and with the exception of Stoddard Solvent the chemicals were diluted with water and applied at the rate of 50 gallons per acre. The weed population consisted mainly of lamb's quarters, purslane, pigweed, galinsoga, smartweed, and annual grasses. It was quite evident that with the exception of Dacthol the treatments were very effective in controlling weeds. Considerable crop injury was apparent, however, by June 9 when plant injury ratings were recorded. A rating of "7" or better in weed control and crop appearance is considered as necessary to be acceptable commercially. Of the 22 treatments in the test only 4 met these requirements and are listed as follows: 2 pounds of B562, 2 pounds of Karsil, and 10 and 15 pounds of Zytron. It was quite interesting to note that 100 gallons of Stoddard Solvent appeared to cause some crop injury and also affected yields adversely in this test.

Lettuce

Pennlake lettuce was seeded in the plots on April 26 and the pre- and post-emergence weed sprays were applied on April 28 and May 20 respectively. Results are presented in Table II. Here again it was evident that the treatments, excepting Vegadex, were very effective in promoting good weed control. Crop damage, however, was particularly evident by June 1 and this effect was also reflected in reduced yields.

Based on the tenet that weed control and crop appearance must rate 7 or more without sacrificing crop yield only the treatment involving 3 pounds of Amiben met these requirements.

[1]Contribution No. 1278. Massachusetts Agricultural Experiment Station.

[2]Professor and Technical Assistant, respectively.

TABLE I - WEED CONTROL AND GROWTH OF CARROTS

Planted May 4, 1960 - Sprayed Pre-emerg. May 5, 1960
Post-emerg. May 25, 1960 - Recorded June 9, 1960
(3 Replications)

Rate	Product	Source	Time Applied	Weed Control 1-Poor to 9-Excellent	Crop Appear. 1-Poor to 9-Excellent	Total Yield Lbs.
1.0 Lbs.	9S4	Naug. Chem.	Post-emerg.	6.0	8.0	96
2.0 "	"	" "	" "	8.0	3.7	65
2.0 "	B562	" "	" "	8.0	7.0	74
4.0 "	"	" "	" "	8.3	2.7	45
1.0 Gal.	Randox T	Monsan.	Pre-emerg.	6.7	7.4	93
4.0 Lbs.	Amiben	Amchem	" "	7.3	6.7	88
6.0 "	"	"	" "	7.7	4.7	82
8.0 "	"	"	" "	8.0	2.3	71
2.0 "	Karsil	Niag.	Post-emerg.	9.0	7.0	87
4.0 "	"	"	" "	9.0	5.3	73
4.0 "	"	"	" "	9.0	5.0	72
plus 4.0 lbs. after 14 days						
2.0 Lbs.	Dicryl	Niag.	Post-emerg.	8.3	4.0	77
2.0 "	"	"	" "	8.7	3.3	64
plus 2.0 lbs. after 14 days						
4.0 Lbs.	Dicryl	Niag.	" "	8.7	2.0	38
plus 4.0 lbs. after 14 days						
1.5 Lbs.	G-30031	Geigy	" "	9.0	6.7	72
2.0 "	"	"	" "	8.3	5.7	74
10.0 "	Zytron	Dow	Pre-emerg.	7.3	8.3	100
15.0 "	"	"	" "	7.3	8.0	84
4.0 "	Dacthol	Dia. Alk.	" "	2.7	8.3	87
8.0 "	"	" "	" "	3.0	8.0	85
12.0 "	"	" "	" "	2.7	8.7	92
100 Gals.	Stoddard Solvent		Post-emerg.	8.3	6.3	60
L.S.D. @ .05				1.1	1.6	10.8
L.S.D. @ .01				1.5	2.1	15.7

TABLE II - WEED CONTROL AND GROWTH OF LETTUCE

Planted April 26, 1960 - Sprayed Pre-emerg. April 28, 1960
Post-emerg. May 20, 1960 - Recorded June 1, 1960
(4 Replications)

Rate	Product	Source	Time Applied	Weed Control 1-Poor to 9-Excellent	Crop Appear. 1-Poor to 9-Excellent	Total Yield Lbs.
4.0 Lbs.	Vegadex	Monsan.	Pre-emerg.	5.5	8.0	110.1
6.0 "	"	"	" "	6.5	8.0	125.6
3.0 "	Amiben	Amchem	" "	7.3	7.3	112.1
4.0 "	"	"	" "	8.3	5.5	110.0
1.0 "	9S4	Naug. Chem.	Post-emerg.	8.0	5.3	115.7
2.0 "	"	" "	" "	8.5	3.5	102.1
2.0 "	B562	" "	" "	8.3	3.0	79.7
4.0 "	"	" "	" "	8.8	2.0	82.6
10.0 "	Zytron	Dow	" "	7.3	2.8	79.2
15.0 "	"	"	" "	8.5	1.0	2.4
Check - Cultivated				9.0	9.0	100.7
Check - Uncultivated				1.0	8.5	
L.S.D. @ .05				1.1	1.0	23.4
L.S.D. @ .01				1.5	1.4	31.5

TABLE III - WEED CONTROL AND GROWTH OF BEETS

Planted May 3, 1960 - Sprayed May 4, 1960 - Recorded June 3, 1960
(3 Replications)

Rate	Product	Source	Time Applied	Weed Control 1-Poor to 9-Excellent	Crop Appear. 1-Poor to 9-Excellent	Total Yield Lbs.
4.0 Lbs.	CIPC	Columb. So.	Pre-emerg.	4.7	2.3	19.4
4.0 "	Endothal	Penn. Salt	" "	3.0	8.3	101.2
6.0 "	"	" "	" "	6.0	7.4	94.5
4.0 "	Vegadex	" "	" "	7.0	7.4	103.3
6.0 "	"	" "	" "	8.0	7.4	124.6
1.0 "	7442	Hercules	" "	4.7	8.0	108.2
2.0 "	"	"	" "	5.0	7.0	112.4
4.0 "	"	"	" "	7.0	4.3	81.0
Check - Cultivated				9.0	9.0	128.3
Check - Uncultivated				1.0	9.0	95.0
L.S.D. @ .05				2.3	1.6	24.6
L.S.D. @ .01				3.0	2.2	33.8

TABLE IV - WEED CONTROL AND GROWTH OF DIRECT-SEEDED ONIONS

Planted April 26, 1960 - Sprayed April 28, 1960, Pre-emerg.
Post-emerg. May 20, 1960 - Recorded June 3, 1960
(4 Replications)

Rate	Product	Source	Time Applied	Weed Control 1-Poor to 9-Excellent	Crop Appear. 1-Poor to 9-Excellent	Total Yield Lbs.
6.0 Lbs.	Randox	Monsan.	Pre-emerg.	4.3	9.0	130.0
4.5 Qts.	Randox T	"	" "	5.3	8.3	127.4
9.0 "	" "	"	" "	7.8	7.8	127.0
8.0 Lbs.	CIPC	Columb. So.	" "	8.8	7.5	115.6
1.0 "	9S4	Naug. Chem.	Post-emerg.	7.3	7.8	123.5
2.0 "	"	" "	" "	8.0	7.0	107.8
2.0 "	B562	" "	" "	8.0	7.3	110.6
4.0 "	"	" "	" "	9.0	7.3	114.2
10.0 "	Zytron	Dow	Pre-emerg.	8.8	8.3	121.3
15.0 "	"	"	" "	9.0	7.8	116.2
Check - Cultivated				9.0	9.0	132.2
Check - Uncultivated				1.0	9.0	--
L.S.D. @ .05				1.0	1.1	12.2
L.S.D. @ .01				1.3	1.5	16.5

TABLE V - WEED CONTROL AND GROWTH OF SPINACH

Planted April 26, 1960 - Sprayed April 29, 1960 - Recorded June 1, 1960
(4 Replications)

Rate	Product	Source	Time Applied	Weed Control 1-Poor to 9-Excellent	Crop Appear. 1-Poor to 9-Excellent	Total Yield Lbs.
3.0 Lbs.	Vegadex	Monsan.	Pre-emerg.	6.8	7.8	16.9
4.0 "	"	"	" "	7.5	8.5	17.2
2.0 "	CIPC	Columb. So.	" "	4.8	7.3	14.1
1.0 "	7442	Hercules	" "	2.0	8.8	18.9
2.0 "	"	"	" "	5.3	8.5	16.9
4.0 "	"	"	" "	6.0	7.3	11.6
2.0 "	Endothal	Penn. Salt	" "	1.5	8.5	18.1
2.0 "	"	" "	" "	1.3	8.8	16.7
10.0 "	Zytron	Dow	" "	8.3	7.5	12.3
15.0 "	"	"	" "	9.0	3.5	6.3
Check - Cultivated				8.8	9.0	17.4
Check - Uncultivated				1.3	8.3	14.6
L.S.D. @ .05				1.4	1.4	3.2
L.S.D. @ .01				1.9	1.9	4.3

TABLE VI - WEED CONTROL AND GROWTH OF SWEET CORN

Planted June 21, 1960 - Sprayed June 22, 1960 - Recorded July 23, 1960
(3 Replications)

Rate	Product	Source	Time Applied	Weed Control 1-Poor to 9-Excellent	Weed Index*	Total Yield Lbs.
2.0 Lbs.	5996	Niag.	Pre-emerg.	5.7	12.4	34.6
4.0 "	"	"	" "	7.7	1.8	36.6
4.5 Qts.	Randox T	Monsan.	" "	8.0	0.7	41.0
2.0 Lbs.	Atrazine	Geigy	" "	9.0	0.0	38.6
3.0 "	"	"	" "	9.0	0.0	38.6
4.0 "	"	"	" "	9.0	0.0	42.3
1.0 "	Fenac	Amchem	" "	8.3	0.0	40.0
2.0 "	"	"	" "	9.0	0.0	35.3
6.0 "	DN Premerge	Dow	" "	8.3	0.5	35.3
2.0 "	Simazine	Geigy	" "	9.0	0.0	40.3
3.0 "	"	"	" "	9.0	0.0	41.7
4.0 "	"	"	" "	9.0	0.0	39.3
4.0 "	Eptam	Stauffer	" "	8.3	1.8	38.0
6.0 "	"	"	" "	8.3	1.8	39.0
8.0 "	"	"	" "	7.0	4.2	35.3
Check				1.0	38.4	24.0
L.S.D. @ .05				0.8	4.1	7.9
L.S.D. @ .01				1.1	5.5	10.7

* Weed Index = % weed cover x height (cms):100.

Beets

Detroit Dark Red beets were seeded in the plots on May 3 and the herbicides were applied a day later. Results are presented in Table III. Here it appeared that treatments involving 4 and 6 pounds of Vegadex were the only treatments which met our requirements for a herbicide in beets. It is interesting to note that when applied at a different time in the lettuce plots, as described previously, Vegadex did not meet the requirements in controlling weeds. This variability of performance has been characteristic of Vegadex in tests performed here previously; apparently several environmental factors markedly affect the action of this chemical.

Seeded Onions

Seed of Highlight onion, an F_1 hybrid, was planted on April 26 and the plots were sprayed with the pre-emergence weed killers on April 28. Post-emergence sprays were applied on May 20. The weed control and crop appearance ratings were noted on June 3. Results are presented in Table IV.

Randox T at 9 pounds per acre and all of the other treatments which included 8 pounds of CIPC, 1 and 2 pounds of 9S4, 2 and 4 pounds of B562, and 10 and 15 pounds of Zytron all controlled weeds well until June 3 without appreciable crop injury. Treatments which included 2 pounds of 9S4, 2 and 4 pounds of B562, 8 pounds of CIPC and 15 pounds of Zytron, however, were the poorest yielding plots. Regular Randox did not injure the crop nor were yields affected adversely but weed control was poorest among the treatments.

Spinach

Seed of America spinach was planted in the plots on April 26. The herbicides were applied pre-emergence on April 29. Results are presented in Table V. In these tests 4 pounds of Vegadex promoted good weed control with no apparent injury or reduction in crop yield. Zytron at 10 pounds per acre appeared to have possibilities until it was ascertained that this chemical reduced the yield significantly.

Sweet Corn

Sugar King sweet corn seed was planted in the plots on June 21 and the herbicides were applied pre-emergence on June 22. Ideal soil moisture conditions and other favorable environmental influences undoubtedly were responsible for the remarkable results (Table VI) encountered in these tests. Among the treatments only 2 pounds of Niagara 5996 failed to give good weed control. Both Atrazine and Simazine at 2, 3 and 4 pounds active ingredient per acre prevented weed growth entirely. Among the various treatments only the crop harvested from the check plots was affected adversely in marketable yield.

Conclusions

The results published here should not be interpreted as a final assessment of the chemicals involved in the tests since the balance of environmental influences are extremely important in determining the value of many herbicides. Either plus or minus minor to major variations might be expected from trials conducted under other conditions. Therefore, tests conducted over a period of years are necessary to evaluate the potential of each product.

Chemical Weed Control In Direct Seeded And Transplanted Broccoli[1]

S. L. Dallyn and R. L. Sawyer

Cornell University - Long Island Vegetable Research Farm

The cole crops - cauliflower, broccoli, brussels sprouts, and cabbage have long been of major importance in the agricultural economy of Long Island. Traditionally they have been grown primarily in the fall and with the transplant system of culture. Both these factors have favored reasonably satisfactory weed control with mechanical equipment plus, perhaps, one or two hand hoeings in the more weedy fields. Recently there has been a marked increase in production of spring and summer cabbage and with it an increased weed problem. Also, interest has risen in the possibilities of direct seeding as a method of reducing production costs and labor requirement. This practice would be effective only with availability of an efficient herbicide.

This station has had a project on cole crop herbicides for approximately 15 years. Progress during the first ten was limited primarily to the conclusion that these crops were among the most sensitive to herbicides then available. The two materials CIPC and CDEC produced the first encouraging results and more recently a number of others have shown some promise - among them Eptam, Dacthol, and Amibin. As part of a project on broccoli production the performance of a number of herbicides on this crop was studied in 1960.

Methods: The experiments were conducted on Sassafras loam with the variety Waltham 29 used in both a direct seeded and a transplanted trial. Plant spacing was 12 inches in the row, 34 inches between rows. Plots of single, 20-foot rows were replicated three times. Principal weeds in the area were annual grasses and pusley.

The direct seeded trial was planted June 22, treated immediately and watered in with one-half inch of irrigation. The transplant trial was set in the field August 1 and the Eptam applied and incorporated into fairly dry soil on August 9. Rain, 0.6 inches, fell during the night of August 10 and the remainder of the treatments were applied to moist soil the next day. On one-half of each plot receiving Stauffer 2061 the material was incorporated into the soil. Granulars were applied directly over the plants; the sprays directed from each side to overlap about one inch up the stem. Observations on weed control and crop response were made at intervals during the growing season. Both plantings suffered some damage from the hurricane on September 12. Harvest data were taken on the center heads only. Harvest period for the direct seeded trial was September 9 to October 25, for the transplanted September 20 to October 31.

Results and Discussion: The data for the direct seeded trial are summarized in table 1. Several of the treatments reduced crop stand. A certain amount of chemical thinning might actually be an advantage if it could be reliably controlled. Anything with a rating of 3.0 or over in this catagory would be considered questionable, however, as there would always be the

[1] Paper No. 445, Department of Vegetable Crops, Cornell University, Ithaca, N.Y.

possibility of too severe thinning under some conditions. Surviving plants, in most cases, grew normally; exceptions were those treated with atrazine and to a lesser extent amiben and simazine. Dacthal did not give sufficient weed control at the rates used. Amibin, dinobin and atrazine caused too much crop damage. Simazine was borderline - a tendency for some crop injury and only fair weed control. Dicryl, Vegadex, and 2061 performed reasonably well; Trietazine and 15336 looked promising.

Atrazine was the only material to cause any acute injury on the transplanted crop. The damage first appeared about one week after treatment and got progressively worse until the plants were killed. The only apparent effect of Eptam was the lack of bloom on the leaves. Trietazine and simazine at the higher rates caused some stunting. All materials gave reasonably satisfactory weed control up until September 10 when the plants were hilled. Control beyond that point is relatively easy with mechanical equipment. Incorporation of 2061 did not appear to change its performance over that of surface application.

Table 1. Effect of several herbicides, applied at planting, on weed control and crop response with direct seeded broccoli.

Treatment			Crop[1] Stand	Crop Injury July 10	Weed Control[2] July 10	Weed Control[2] July 25	Yield No. #1 Heads
Dacthal	2 lb./A.	gran.	1	1	2.0	1.0	17
"	4 "	"	1	1	2.0	1.0	19
"	6 "	"	2	1	2.5	1.5	20
Amibin	2 "	"	3	2.5	4.5	3.5	15
"	4 "	"	4	3	5.0	4.5	11
Dinoben	2 "	"	2	2	2.5	2.0	21
"	4 "	"	3	2.5	4.5	4.0	23
Trietazine	1½ "	"	2	2	3.5	2.0	21
"	3 "	"	2	2.5	4.5	4.0	20
Simazine	1 "	"	2	2	2.0	1.5	17
"	2 "	"	2.5	3	3.0	1.5	14
Atrazine	1 "	"	2	3	3.5	2.5	15
"	2 "	"	4	4	4.5	3.5	5
Stauffer 2061	2 "	liquid	1	2	3.0	2.0	16
"	4 "	"	2	2	3.0	2.0	17
Vegadex	4 "	"	1	1	3.5	2.5	24
Dicryl	4 "	"	2	1	4.0	2.5	19
Monsanto 15336	4 "	"	1	1	3.0	2.0	20
" "	8 "	"	2	1	4.0	3.5	25
Check			1	1	1.0	1.0	26
				L.S.D. 5%			9

[1] 1 = no reduction 2 = slight reduction - 12" stand after thinning attainable
3 = moderate reduction - 12" stand after thinning not always attainable.
4 = severe
5 = 0 - 10% stand

[2] 1 = no control 5 = complete control

Table 2. Effect of several herbicides on weed control and crop response with transplanted broccoli.

Treatment				Crop[1] Injury	Weed[2] Control	Yield #1 Broccoli No. Heads	Wt.-Lbs.
Dacthal	4	lbs/A.	gran.	1	3.0	19	10.9
"	8	"	"	1	3.0	18	12.5
"	12	"	"	1	4.0	25	16.8
Amibin	2	"	"	1	4.0	15	10.8
"	4	"	"	1	5.0	16	12.2
Dinoben	2	"	"	1	4.0	16	10.4
"	4	"	"	1	4.0	21	12.6
Trietazine	1.5	"	"	1	4.0	18	10.4
"	3	"	"	2	5.0	19	7.8
Simazine	1	"	"	1	4.0	20	11.4
"	2	"	"	1	4.5	8	2.8
Atrazine	1	"	"	3	5.0	2	0.8
"	2	"	"	5	5.0	0	0
Monsanto 15336	4	"	liq.	1	2.0	12	8.6
"	8	"	"	1	3.0	18	12.0
Vegadex	4	"	"	1	3.5	24	14.7
Dicryl	4	"	"	1	3.5	14	10.2
Stauffer 2061	4	"	"	1	3.0	19	12.3
" "	8	"	"	1	4.0	20	12.2
Eptam	4	"	"	2	4.0	21	13.9
"	4	"	gran.	2	4.5	24	19.0
Check				1	1.0	19	13.2
	L.S.D. 5%					9	4.9

[1] 1 = no injury 5 = severe

[2] 1 = no control 5 = complete control

Summary: Dicryl, Vegadex, Stauffer 2061, Trietazine, and Monsanto 15336 looked promising for weed control in direct seeded broccoli. Dacthal did not injure the crop but rates used were too low for satisfactory weed control.

Amibin, dinobin, Dacthal, Monsanto 15336, Stauffer 2061, Vegadex, and Dicryl performed well, applied to well established transplanted broccoli.

PRE-EMERGENCE WEED CONTROL IN CORN

S. M. Raleigh[1]

The 1960 pre-emergence weed control treatments were similar to the plots established in the late forties and early fifties because of the interest in granular 2, 4-D.

The first 2, 4-D pre-emergence weed control in corn in the United States was done by J.C. Anderson and D.E. Wolf in New Jersey in 1946. The 2, 4-D was applied just before emergence. From 1947 to 1955, many investigators in the northeast applied 2, 4-D at planting time and also just before emergence of the corn. Since 1955, very little work has been done with 2, 4-D at planting time because of the chances of more injury to the corn.

The corn in 1960 was planted with a four row planter. The center two rows were treated and the edge rows left as checks. The results given in Table I were obtained by counting weeds in the treated rows and adjacent untreated rows to obtain the per cent control. There was a good stand of broadleaf weeds in all areas, but grass population was scattered.

The treatments marked early were applied the day of planting. All other treatments were applied just before "come up" of the corn.

Granular 2, 4-D and liquid 2, 4-D reacted in a very similar manner. The corn in these plots was slightly stunted when the plants were 4-5 inches tall, later in the season you could see no injury. If you did not have nontreated rows next to the treated area, you could not see the stunting.

Atrazine and simazine were outstanding in controlling both broadleaf and grassy weeds. Granular simazine was somewhat poorer than simazine 80W.

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Table I Percent Weedcontrol with pre-emergence herbicides
University Park, Pennsylvania

Chemical	Rate	Low Broadleaf	Low Grass	Medium Broadleaf	Medium Grass	High Broadleaf	High Grass
24-D granular quick (early)	1,2,3,(lb/ac)	46	49	38	19	80	07
24-D granular slow (early)	1,2,3(lb/ac)	36	0	79	27	79	14
24-D LV4	1,2,3(lb/ac)	87	0	100	24	100	36
24-D LV4 (early)	1,2,3(lb/ac)	38	8	100	0	91	0
24-D amine	1,2,3(lb/ac)	78	35	91	06	56	04
24-D amine (early)	1,2,3(lb/ac)	72	0	76	0	93	0
Benzac	1,2,3(lb/ac)	96	0	100	26	100	0
Simazine	1,2,3(lb/ac)	100	97	100	100	100	100
Simazine granular	1,2,3(lb/ac)	96	77	100	100	100	98
Atrazine	1,2,3(lb/ac)	100	97	100	100	100	100
Fenac	1,2,3(lb/ac)	91	26	100	69	100	18
ACP-M675	1,2,3(lb/ac)	47	0	100	0	20	05
ACP-M822	1,2,3(lb/ac)	100	0	100	0	100	0
ACP-M848	1,2,3(lb/ac)	96	0	100	0	100	0
Randox	2,4,6(lb/ac)	0	04	50	22	23	18
Randox-T	2,4,6(qt/ac)	29	25	50	32	100	58
Hercules 7442	1,2,3(lb/ac)	31	0	25	24	58	0
Dacthal	2,4,6,(lb/ac)	32	39	30	36	0	44
Carbyne	1,2,3(lb/ac)	19	0	0	0	07	0

INCORPORATED AND UNINCORPORATED LIQUID AND GRANULAR CARRIERS OF EPTC AND SEVERAL ANALOGS ON WEED CONTROL AND CORN INJURY

Richard D. Ilnicki[1] and Richard W. Chase[2]

ABSTRACT

Two techniques have been introduced which substantially advanced the field of chemical weed control. They are the use of the granular carrier and the feature of incorporating herbicides into the upper soil surface before or immediately after planting. The technique of incorporation became established with the advent of ethyl N,N-di-n-propylthiolcarbamate (EPTC), a very effective but highly volatile herbicide.

Since the release of EPTC several related analogs have become available to research workers for evaluation. The objectives of this study were as follows: (1) to evaluate these new analogs along with EPTC as herbicides; (2) to determine the effects of the carrier on their activity; (3) to measure the effects of incorporation on activity; and (4) to determine the effects of carrier and incorporation on activity.

EPTC, n-propyl di-n-propylthiolcarbamate (R-1607), ethyl ethyl-n-butylthiolcarbamate (R-2060), and propyl ethyl-n-butylthiolcarbamate (R-2061) were applied as the liquid (emulsifiable concentrate) and as a granular (5% on atta clay), two days after corn planting, at rates of 4 and 6 pounds per acre of the active ingredient. Weed control and corn injury were used as criteria of activity.

The following observations were made: (1) granular preparations effected greater weed control and corn injury than the liquid preparations; (2) no liquid preparation injured corn to any degree when not incorporated; (3) when liquid preparations were incorporated the degree of weed control approached that of the unincorporated granular preparations; (4) incorporating the granulars only slightly improved the weed control over the unincorporated granulars; (5) there was slight injury to corn from unincorporated granulars at the high rate; and (6) injury to corn was more severe with incorporated granulars than with incorporated liquids.

EPTC was the most active herbicide and R-2060 was the least active compound. R-1607 and R-2061 were intermediate with the former slightly superior to the latter.

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Comparisons of Spray and Granular Applications of Certain Herbicides for Weed Control in Corn 4/

Frank B. Springer, Jr. and
Richard H. Cole 1/

Much has been written in popular periodicals concerning the virtues of granular herbicides vs liquid herbicides for use in controlling broadleaf weeds and grasses in corn. It is agreed that several herbicides previously available only in the liquid state or wettable powders are effective in controlling both broadleaf weeds and grasses when applied in either pre-emergence or post emergence applications but the effectiveness of their counterparts in the granular form is presently being evaluated.

Procedure

In 1960 three herbicides applied in solution were compared with the granular formulation of the same herbicides and then a comparison of these was made with an effective herbicide and an untreated control plot.

Pre-emergence treatments of 2,4-D butyl ester solution and granular (2,4-dichlorophenoxyacetic acid butyl ester), CDAA 2/ (a-Chloro-N-N diallylacetamide) solution and granular, CDAA-T 3/ (a-Chloro-N-N diallylacetamide and trichlorobenzyl chloride) solution and granular, and atrazine (2-chloro-4-ethylamino-6-isopropylamino-S-triazine) were evaluated at Newark and Georgetown, Delaware, at rates indicated in Table 1. The soil in the experimental areas was a Matapeake silt loam at Newark and a Norfolk sandy loam at Georgetown, Delaware. The plots consisted of 4 rows, each 18 ft. long and spaced 3 ft. apart. The hybrid was Conn. 870, planted May 11, 1960, at Georgetown and May 19, 1960, at Newark. Herbicides were applied the day following planting. A modified bicycle type experimental plot sprayer was used for those chemicals applied in solution. The low concentration of each herbicide applied in solution was applied in 20 gal. of water per acre and the double concentration was applied in 40 gal. of water per acre. The double concentration was applied by spraying the designated

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1/ Assistant Agronomist and Assistant Professor, University of Delaware.

2/ CDAA applied as Randox, courtesy of the Monsanto Chemical Co., Organic Chemicals Division, St. Louis, Mo.

3/ CDAA-T applied as Randox-T, courtesy of the Monsanto Chemical Co., Organic Chemicals Division, St. Louis, Mo.

4/ Misc. Paper No. 374, Del. Agr. Exp. Sta.

Table 1. Weed Control Ratings and Yields of Corn as Affected by Spray and Granular Forms of Certain Herbicides at Newark and Georgetown, Delaware, 1960.

Treatment	Rate	Broadleaf Ratings 1/			Grass Ratings 1/			Yield
		June 29 Newark	Sept. 20 Newark	June 28 Georgetown	June 29 Newark	Sept. 20 Newark	June 28 Georgetown	Bu./A. Newark
2,4-D ester	1/2	0.0	3.3 (S)	2.3	0.0	1.7	0.0	38.2
	1	0.0	3.7 (S)	3.3	0.0	1.7	0.0	49.5
2,4-D granular	1/2	6.3	6.7 (S)	0.0	1.3	2.7	0.0	57.6
	1	7.0	5.0 (S)	0.3	4.3	3.7	0.3	66.5
CDAA	4	3.3	4.0	0.3	3.0	7.7	0.3	60.6
	8	6.4	4.7	0.3	7.0	3.7	0.3	79.4
CDAA granular	4	2.7	1.3 (S)	2.0	2.7	3.7	2.3	57.3
	8	3.3	2.0 (S)	3.0	3.3	4.7	3.3	71.2
CDAA-T	4	10.0	8.3	9.7	7.3	4.3	3.3	66.7
	8	10.0	9.3	10.0	8.7	5.3	5.7	73.2
CDAA-T granular	4	10.0	4.7	5.0	10.0	6.3	1.7	74.9
	8	10.0 (S)	6.7 (S)	6.7	10.0	7.3	3.0	80.5
Atrazine	2	10.0	5.7	10.0	9.0	7.0	3.0	85.6
	4	10.0	7.0	10.0	10.0	7.7	9.7	83.2
Control	---	0.0	0.0	0.0	0.0	0.0	0.0	23.2
Significance - .05								31.4

1/ 0 = no control, 10 = perfect control
(S) = stunting of corn

plots twice using the single rate calibration on the sprayer. The granular materials were applied by hand, using a shaker to evenly distribute the herbicide over the plot area.

The weed control ratings were taken June 28, 1960, at Georgetown and June 29, 1960, at Newark, approximately six weeks following planting. Fall weed ratings were taken at Newark, September 20, 1960. These data are summarized in Table 1. No data other than weed ratings were taken at Georgetown since a poor stand was present over the entire experimental area. Soil moisture at the time of planting was adequate for germination of corn and weeds. One half inch of rainfall followed application of chemicals at both locations. At Newark all plots received one cultivation after the weed ratings were taken.

Broadleaf weeds predominating were pigweed (*Amaranthus retroflexus*), ragweed (*Ambrosia artemisiifolia*), and lamb's quarters (*Chenopodium album*). The predominant grasses were crabgrass (*Digitaria sanguinalis*), yellow foxtail (*Setaria lutescens*), and a light infestation of nutgrass (*Cyperus esculentus*).

Results and Discussion

The performance of herbicides is summarized in Table 1. These data indicate that 2,4-D ester (solution) at both rates, CDAA (solution) at 4 lbs. per acre and CDAA (granular) at both rates gave ineffective control of both broadleaf weeds and grasses. The granular form of 2,4-D was fair in the control of broadleaf weeds at both rates but unsatisfactory in grass control. CDAA-T (solution), CDAA-T granular, and Atrazine gave very effective control of both broadleaf weeds and grasses at Newark at both rates. CDAA-T (solution) was very effective on broadleaf weeds and ineffective on grasses at Georgetown. CDAA-T granular was not effective on either broadleaf weeds or grasses at Georgetown. It is obvious that when weeds are adequately controlled high yields can be expected if moisture and fertility are adequate. Plants were observed to be stunted in the 2,4-D ester (solution), 2,4-D (granular) and CDAA granular treatments at both rates of application when the September 20 weed ratings were taken. This stunting was undoubtedly caused by the lack of weed control thus allowing weeds to compete for moisture and plant nutrients. Stunting of plants was observed at the high rate of CDAA-T granular at both weed rating dates at Newark, however yield was not affected by this apparent chemical injury.

Summary

This study indicates that the herbicides in the test applied in granular form did not seem to be more effective in controlling weeds than the same herbicides applied in solution with the exception of 2,4-D granular. The granular form of 2,4-D was slightly more effective in controlling broadleaf weeds and grasses at the Newark location than was 2,4-D in solution.

THE EFFECTS OF SEVERAL CARRIERS OF 2,4-D AND ITS FORMULATIONS ON WEED CONTROL AND ON THE RESPONSE OF CORN

Richard D. Ilnicki[1] and C. Fred Everett[2]

ABSTRACT

The use of 2,4-dichlorophenoxyacetic acid (2,4-D) for the control of weeds in corn has become an accepted practice. Corn is classified as being moderately resistant to injury from this herbicide. Generally, post-emergence applications of 2,4-D are safe; however, pre-emergence applications on light soils, followed by excessive rains may cause severe injury. Since the advent of the granular carrier considerable interest has been given to granular preparations of herbicides in order to increase herbicidal activity and/or to reduce crop injury.

The objectives of this study were to measure herbicidal activity and the response of corn to several formulations, carriers, and concentrations of 2,4-D. The following comparisons were made: liquid vs. granular preparations of both esters and amines; a 10% vs. a 20% ester granule; and slow vs. fast disintegrating granules of the parent acid. Rates of 2 and 4 pounds per acre of the acid equivalent were applied the day after planting.

The following observations were made: in general, granular preparations, both of the esters and amines, produced slightly better weed control but effected greater injury to corn than the liquid preparations; the 10% granular ester preparation gave better weed control with slightly more injury to corn than the 20% granular ester; better weed control with less corn injury was obtained with the liquid ester than with the 20% granular ester preparation; and, the slow disintegrating granule was superior to the fast disintegrating granule, however, yield reductions were less with the latter.

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DNBP - Zytron Mixture for Weed Control in Soybeans [3/]

F. B. Springer, Jr. and R. H. Cole [1/]

Over one-third of the soybean fields in Delaware were described as having inadequate weed control in two 1960 surveys (1). In one-eighth of the total fields visited, both broadleaf weeds and grasses were found in high populations. As no one chemical has been found to satisfactorily control both broadleaves and grasses, effective treatment for the control of both may be possible by a combination of chemicals as suggested by Indyk (2). DNBP [2/], a satisfactory chemical for the control of broadleaf weeds, was recommended for trial use in Delaware in 1960 (4). Zytron (Dow M-1329), described by Wiltse (5), gave good grass control without soybean injury in the 1959 Maryland results (3). A combination of DNBP and Zytron was used in the 1960 pre-emergence weed control studies at Newark and Georgetown, Delaware.

Procedure

The rates of chemicals applied at two Delaware locations are recorded in Table 1. A recommended variety (Clark at Newark, Hill at Georgetown) was planted in 4 row x 18 foot plots with three replications. Pre-emergence liquid applications of chemicals were made one day following planting. At both locations, heavy rainfall was received within two days of chemical application. Rainfall for the summer months was slightly above average at both locations and well distributed. Phosphorus, potash and lime were applied in compliance with recommended practices. Uniform stands were obtained and maintained in all treatments.

Table 1. Rates in pounds per acre of chemicals used in the 1960 pre-emergence weed control studies

	Low Rate	High Rate
DNBP	3	6
Zytron (Dow M-1329)	5	10
Combination		
DNBP and	3	6
Zytron (Dow M-1329)	5	10
Check (two cultivations)	0	0

1/ Assistant Agronomist and Assistant Professor, University of Delaware.

2/ DNBP applied as Premerge, courtesy of the Dow Chemical Co., Midland, Michigan.

3/ Misc. Paper No. 372, Del. Agr. Exp. Sta.

Weed control ratings were made five weeks following planting and at harvest time at both locations. Combined results are found in Table 2. Yield results are reported separately for each location (Table 3).

Table 2. Weed control ratings (0 = no control, 10 = perfect control).

	Low Rate	High Rate
Broadleaf Control		
DNBP	8	9
Zytron	2	7
Combination	9	9
Check	0	0
Grass Control		
DNBP	2	4
Zytron	4	8
Combination	9	10
Check	0	0

Broadleaf weeds predominant at both locations were pigweed (*Amaranthus retroflexus*), ragweed (*Ambrosia artemisiifolia*), lamb's quarters (*Chenopodium album*) and morning glory (*Ipomoea purpurea*). Crabgrass (*Digitaria spp.*) and foxtail (*Setaria lutescens*) were the principal grasses present.

Results and Discussion

All weeds were satisfactorily controlled by the combination of the two chemicals except morning glory. The high rate of all chemicals gave good broadleaf control while very good control was obtained by DNBP at the 3 lbs./A. rate (Table 2). The 10 lbs./A. rate of Zytron and the combination of chemicals at either rate gave good grass control.

Yields from Newark (Table 3) apparently reflect the high broadleaf weed populations. At this location the 3 lbs./A. rate of DNBP or the 10 lbs./A. rate of Zytron gave satisfactory weed control. The stunting observed from the 6 lbs./A. rate of DNBP did not significantly reduce yields.

Results from Georgetown (Table 3) differ in many aspects from Newark because of the high grass population present. As at Newark, the 10 lbs./A. rate of Zytron gave significantly greater yield than the 5 lbs./A. rate of the chemical. Although stunting was observed at both rates with DNBP an appreciably (but not significantly) greater yield was found at the 6 lbs./A. rate. This may have been because of the slightly better grass control at the 6 lbs./A. rate.

Table 3. Yield in bushels per acre of soybeans at two Delaware locations. Averages of three replications.

	Low Rate	High Rate
Newark, Delaware		
DNBP	38.2	35.9 (S)
Zytron	14.1	35.8
Combination	36.7	39.7 (S)
Check	23.6	23.6
Significance, 5%		
Within rates	11.7	Not significant
Between rates	13.5	
Georgetown, Delaware		
DNBP	29.7 (S)	37.2 (S)
Zytron	31.4 (V)	42.4 (V)
Combination	41.3 (V)	43.4 (V)
Check	22.8	22.8
Significance, 5%		
Within rates	11.2	8.7
Between rates	10.6	

(S) Stunting of soybeans at the end of the five week period following planting.

(V) Increased vigor of soybeans at the end of the five and ten week period following planting.

While Zytron gave good control of both broadleaves and grasses at the 10 lbs./A. rate, the combination of Zytron at 10 lbs./A. plus DNBP at 3 lbs./A. gave as good weed control and approximately equal yields.

At both rates when Zytron was applied alone or included in a combination at Georgetown there was an increased vigor noted in the soybean plants at the end of the fifth and tenth weeks following planting. At present no evidence has been produced to determine exact reasons for this phenomenon.

Summary

Two rates of DNBP and Zytron and combinations or mixtures of each were evaluated at Georgetown and Newark, Delaware, in 1960. The 3 lbs./A. rate of DNBP and 10 lbs./A. rate of Zytron gave good broadleaf weed control. Good grass control was obtained by the 10 lbs./A. rate of Zytron and the 3 lbs./A. rate of the two chemicals combined.

The combination of DNBP and Zytron may be desirable in areas where both grasses and broadleaf weeds are a problem. Yield increases resulted from the use of chemicals at both locations but demonstrated the need of knowing what weed needs to be controlled before deciding what and how much chemical to apply. No chemical or combination in this study was effective against the morning glory.

All Zytron treatments at Georgetown showed an increased vigor at the end of five and ten week periods following planting, but the exact reasons for these results were not determined. The stunting observed in DNBP plots at the end of the five week period was not reflected in crop yields.

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Weed Control in Soybeans with DNBP Over a Five-Year Period [3/]

F. B. Springer, Jr., H. W. Indyk, R. H. Cole and C. D. Kesler [1/]

Procedure

For the five-year period, 1956 - 1960, DNBP [2/] (amine salt of dinitro-ortho-secondary-butyl-phenol) has been evaluated as a pre-emergence treatment in controlling weeds in soybeans at two locations in Delaware. The soil type at the Newark location was a Matapeake silt loam and at the Georgetown location, a Norfolk sandy loam. The plot size was eighteen feet long with four rows, three feet apart. The chemical was applied as a pre-emergence spray at the 3 lbs./A. and 6 lbs./A. rate on the day of or day following planting. Weed control ratings were taken approximately five weeks after planting and all plots received one or two cultivations following the weed ratings.

The broadleaf weed population at the experimental locations consisted of rough pigweed (Amaranthus retroflexus), common ragweed (Ambrosia artemisiifolia), lamb's quarter (Chenopodium album), and annual morning glory (Ipomoea purpurea). Grass weed population consisted of yellow foxtail (Setaria lutescens), crabgrass (Digitaria sanguinalis), and yellow nutgrass (Cyperus esculentus). These same weeds cause the most trouble in soybeans for Delaware farmers and often become a serious problem. Where severe weed infestation cannot be controlled by cultural methods the use of chemicals may be profitable. Chemical weed control in soybeans is desirable for the following reasons: to increase yields; to make cultivation easier; to allow harvesting of beans when mature; and to help eliminate weeds in certified fields.

Results and Discussion

The results of the past five years indicate satisfactory results with DNBP. The effectiveness of DNBP was outstanding among all the herbicides evaluated at the two locations. At the six pound rate, excellent control of weed growth, particularly rough pigweed, ragweed, and lamb's quarter, was obtained without any harmful effects on yield. The higher rate

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2/ DNBP applied as Premerge, courtesy of the Dow Chemical Co., Midland, Michigan.

3/ Misc. Paper No. 373, Del. Agr. Exp. Sta.

was consistantly better than the lower rate in controlling broadleaf weeds. (Table 1). The three pound rate plots, on the other hand, produced a yield significantly better than the control plots. The plots receiving the six pound rate produced yields which were not significantly better than the plots where the three pound rate had been applied (Table 1). The control of grasses was not as satisfactory at either rate as the control of broadleaf weeds. Although there was slight damage to the soybean plants at emergence with both rates the damage did not affect the stand or yield.

Table 1. Average weed control ratings and yields of soybeans, as affected by DNBP, at Newark and Georgetown. Averages of three replications, 1956 - 1960.

Treatment	Broadleaf Weeds 1/	Grasses 1/	Yield Bu./A.
Control	0	0	20.6
Premerge (3 lbs.)	7.3	3.5	28.0
Premerge (6 lbs.)	8.8	6.0	30.2
5% Significance			2.9

1/ Weed control ratings (0 = no control, 10 = perfect control)

Summary

Five years of tests and field observations throughout the state of Delaware indicate that DNBP at the rate of 3 lbs./A. is satisfactory for controlling broadleaf weeds in soybeans where a mild infestation occurs. Where broadleaf weeds are a severe problem 6 lbs. per acre is most satisfactory in controlling weeds. DNBP sold under the trade names of Premerge and Sinox PE is probably the best answer presently to our broadleaf weed problem in soybeans.

EFFECT OF HERBICIDES ON SEED PRODUCTION IN BIRDSFOOT TREFOIL[1]

T. R. Flanagan[2]

The use of birdsfoot trefoil, Lotus corniculatus (L.), has increased rapidly in the Northeast during the last few years. This is especially true of its use as a cash seed crop.

Most recent is the increase in grower awareness of the multiple problems associated with pest control in seed production fields. Predominant among the many hazards are insect and plant pests. The problems associated with the former have been the subject of a recent study at this station (3).

Plant pest control encompasses both weed control at seeding, and the control of unwanted plants in the established seed production fields. Such plants are competitive grasses, noxious and other weeds, and extraneous forage plants contributing foreign seed which must be cleaned out of the final harvest, often at a considerable loss in shrinkage of seed yield. It is the control of these undesirable plants that is the subject of this paper.

Dalapon has been in general use in the northeast to control grasses and alsike clover in trefoil seed fields. Some use has been made of the phenoxyacetics and phenoxybutyrics for broadleaf plant control. Fertig et al.(1) concluded from the 1958 and 1959 studies of the experimental work in Essex County, New York, that late fall treatments were definitely safer with regard to trefoil injury than spring applications, and that Empire was more tolerant than European type trefoil (Viking). Applications of 6 and 9 pounds per acre active of 4-(2,4-DB) were only moderately effective on dandelion, chicory and yellow rocket. At these rates, considerable stand reduction occurred for the trefoil. Schreiber (4) reported on spring applications of dalapon with rates up to 5 pounds active ingredient. Grass control was effective and residues in the trefoil were less than 25 ppm when the interval between treatment and harvest exceeded 100 days.

Vermont growers have been using herbicides with effective results shown in yields of cleaner seed but with no certain knowledge whether these spray applications affected the quantity of seed produced. The following experiments were conducted to determine whether spring applications of insecticides and herbicides alone and in combinations were detrimental to seed yield. The results of only the observations on herbicides are reported below.

PROCEDURE

Field tests were conducted in 1957, 1959, and 1960 using several herbicides and insecticides alone and in combinations. All spray applications were made with a 20-foot boom mounted on a 4-wheel drive truck, at the rate of 20 gallons per acre, 30 psi, and 4 mph.

[1] Vermont Agricultural Experiment Station Journal Series Paper No. 95
[2] Assistant Agronomist, Vermont Agricultural Experiment Station

The 1957 tests were conducted on a large field of Empire trefoil which had been in production for some years previously. The experimental design was a randomized block with 4 replications. Each plot measured 20 feet in width and 100 feet in length. Seed yields were obtained from five sub-samples cut from each cell, dried at 110° F. for 36 hours, then threshed out by hand. Pesticide materials and rates and date of application are given in Table I.

TABLE I. EFFECT OF APPLICATIONS OF INSECTICIDES AND HERBICIDES ON EMPIRE BIRDSFOOT TREFOIL GROWN FOR SEED.

Pesticide	Pounds Active Ingredient/A.	Pounds Clean Seed/A.
Dalapon	3.00	196.5
Endrin	0.20	
& Dalapon	3.00	133.7
Toxaphene	2.25	
& Dalapon	3.00	154.0
Check	--	94.0

Application date May 2, 1957.
Harvest date July 17, 1957.

The 1959 and 1960 tests were conducted on a large, well established field of Mansfield trefoil, planted in 1954, and in production of registered seed since 1955. Pesticides used, rates per acre, and dates of applications are shown in tables 2 and 3. In the 1959 test the herbicides were applied as sub-plot treatments of a 5 x 5 Latin square with the sub-plots of herbicides measuring 20 x 100 feet. Samples were taken as described for the 1957 trials.

TABLE 2. EFFECTS OF APPLICATIONS OF HERBICIDES ON MANSFIELD BIRDSFOOT TREFOIL GROWN FOR SEED.

Herbicide	Pounds Active Ingredient/A.	Pounds Clean Seed/A.	Pounds Oven-Dry Forage/A.
Dalapon	2.35	148.28	1664
Dalapon	2.35		
& Neburon	2.00	158.96	1705
Dalapon	2.35		
& 4-(2,4-DB)[1]	0.5	136.03	1513

Application date May 5, 1959.
Harvest date July 15, 1959.

[1]Butyrac 118

TABLE 3. EFFECTS OF APPLICATIONS OF HERBICIDES ON MANSFIELD BIRDSFOOT TREFOIL GROWN FOR SEED.

Herbicide	Pounds Active Ingredient/A	Pounds Clean Seed/A	Pounds Oven-Dry Forage/A	Flowers Per Umble#	Pods Per Umble#	Umbles Per Stem
Dalapon	2.35	184.28**	2833**	4.01	12.99	14.57
4-(2,4-DB)[1]	0.5	93.08**	3005**	5.36	7.57	7.69
Dalapon & 4-(2,4-DB)[1]	2.35 0.5	56.77**	2600**	5.69	7.15	7.96
Check	--	362.73**	3503**	2.52	15.05	12.43

Application date May 13, 1960
Harvest date July 16, 1960
Stem counts June 22, 1960

**Significant at the 1% level
#Not analyzed statistically
[1]Butyrac 118

The 1960 tests were conducted in another area of the field described immediately above. The experiment was designed as a randomized block with 5 replications of herbicides as main treatments and insecticides as sub-treatments in strips across the blocks. This design is reported by Leonard and Clark (2) and is particularly adaptable to applying pesticides in long strips across other plots. Rates and dates of application of materials are given in Table 3. Sampling was essentially that as reported above with the reduction of the sub-samples from 5 to 3.

RESULTS AND DISCUSSION

Vermont studies in 1958 (3) and subsequent data[3] indicate that trefoil yields are substantially increased through the use of insecticides. Usually such applications are made in the spring. Applying an herbicide with the insecticide at this same time would seem an economic procedure. Such economics could, however, be offset by any reduction of seed yield resulting from detrimental herbicidal effects. Increases in the final yield of clean seed resulting from the use of an herbicide to control unwanted plants would on the other hand seem to offer an economic practice of merit.

The data gathered in 1957 (Table 1) and in 1959 (Table 2) would seem to support this latter assumption, but subsequent findings are possibly contradictive. The 1957 tests were conducted on a fairly old stand of Empire trefoil which was moderately to heavily infested with weeds and weed grasses. The use of dalapon appeared to be beneficial in the field as fairly good grass suppression was achieved. This is supported by the data in Table 1, but no differences were statistically significant due to considerable fluctuation in yields as influenced by variable results from the separate insecticide applications, several of which have been excluded from the table. Had these been excluded from the experimental design, both dalapon and the dalapon-insecticide combinations would most likely have been statistically significant. Considerable dandelion infestation in the

[3]MacCollom, G. B., Vt. Ag. Exp. Sta. unpublished data.

sprayed plots was indicated by the profuse bloom of this weed. Trefoil bloom was excellent on all plots, as was bee activity. Such differences in yield as occurred can only be attributed to beneficial effects of the dalapon treatments.

The 1959 test was designed unfortunately to primarily test the effectiveness of the insecticides concerned. Neburon and the 4-(2,4-DB) treatments were included to control the dandelion problem. The data as presented in Table 2 again omit results for the various insecticides, not of concern in this report. No check plot for "no herbicide" existed without the presence of an insecticide treatment, but "no treatment" yields in an adjacent trial averaged about 147 pounds of clean trefoil seed per acre.

Several visual estimates of weed species populations were made. The July 9 ratings showed the dandelion stands averaged 15% for the dalapon-DB combinations, 19% for the dalapon alone and 24% for the dalapon-neburon treatments. Grass species present consisted of about a 2:1 tall fescue plus quackgrass mixture which was reduced 50% by the dalapon alone and dalapon-DB combinations. The dalapon-neburon treatments resulted in only 25% grass stand control. Trefoil stand and bloom were excellent for all treatments except those containing neburon. These showed about 10% reduction in bloom. Although not substantiated statistically it would seem from this test that dalapon applied on the same dates with insecticide did not materially damage trefoil seed yields.

The 1960 trials were designed to precisely determine the effectiveness of herbicides applied at the time of insecticide treatment. The data in Table 3 give definite indications, for the first time, that the application of a moderately low rate of dalapon alone or in combination with 4-(2,4-DB) in the late spring to well-established trefoil resulted in lower rather than higher seed yields. This depression in seed yield was also very evident for the use of DB. The most striking yield depressions were seen for the combinations of dalapon plus 4-(2,4-DB), That most loss in seed yield can be attributed to the DB is reflected in the stem counts; the flower, pod and umble count being almost half of that present in the check plots. In comparing the herbicide treatments, the better position of the dalapon alone treatment could be a reflection of the apparent higher index of flowering in contrast with that of the check plots. Other than treatment effects, the trefoil growth was good and adequate bee population was present.

The only grass present in the test area was a fairly uniformly scattered stand of Kentucky bluegrass. All treatments containing dalapon resulted in a 90% stand reduction for this grass. The check plots and dalapon alone treatments were considerably infested with yarrow, prickly lettuce, chicory, and some wild morning glory and buttercup. These weeds were practically eliminated by the DB treatments.

The 1959 herbicide applications were made on May 5 to conform to the date of insecticide application which in turn was made on a predicted 350 degree-day basis (50° F. base). The 1960 applications were made on the same basis but wet field conditions delayed the spray application almost a week, with treatment occurring on May 13. At the time of herbicidal application the trefoil in 1959 was showing approximately 2 inches of new spring growth; in 1960 the growth present when sprayed was at about 4-5 inches. In the 1957 trial, practically no new spring growth was showing on the Empire plants at the time of spray application (May 2).

Since the only appreciable differences between the 1959 and 1960 applications of dalapon on Mansfield birdsfoot trefoil were in the stages of growth existing at the time of application, it might be concluded that this factor could be the reason for the results obtained. Schreiber et al. (4) reported that a 5 pound application of dalapon on Empire trefoil having 1-2 inches of new spring growth resulted in no appreciable injury to the birdsfoot trefoil. In this same study 2.5 and 5 pound per acre applications of dalapon to a 3-year-old Viking stand in the dormant condition, and 17 days later when the trefoil had 4-5 inches of new spring growth, resulted in no noticeable injury. No seed yields were reported, however, although the authors felt that spring applications at low rates resulted in effective grass control.

Timing a spring application of dalapon for control of undesirable grasses and other plant species, to coincide with insecticide application for economic reasons, can be an effective practice, from the standpoint of both weed control and minimal detriment to the trefoil plants and seed yield, apparently only if the trefoil exhibits a minimum of new spring growth. The studies on date of application of insecticides conducted at this station and referred to above indicate that there is considerable leeway in time of their application. Additional studies are needed to determine an optimum date for herbicide application.

CONCLUSIONS

1. Early spring applications of low rates of dalapon to established seed production fields of birdsfoot trefoil effectively control undesirable grasses and certain broadleaf plants.

2. The date for application can be timed to coincide with that of an insecticide application without detrimental effects on plant growth or seed yields.

3. The optimum time for dalapon application is possibly just after the initiation of new spring growth on the trefoil.

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A STUDY OF THE EFFECTS OF VARIOUS RATES AND FORMULATIONS OF CHLORDANE ON NEW STANDS OF TURFGRASS[1]

Paul M. Giordano and C. R. Skogley[2]

The purpose of this investigation was to study the effects of chlordane on several basic turfgrasses. Tests were conducted in the field and under more controlled conditions to determine and evaluate the phytotoxic manifestations of the material when applied at rather high rates and in various formulations.

A field experiment initiated in the fall of 1958 indicated marked differences in percent stand of the grasses treated at herbicidal rates with several chlordane formulations (Table 1). Also, it was noted that species difference was an important factor when treating turf seedbeds with high rates of active material.

A second field study was conducted in the spring of 1960. Similar procedures, materials and rates were employed as in the fall study. Although the results appeared to parallel those of the earlier study turf establishment was more rapid in the spring (Table 2).

Soil samples were taken from treated turf plots of the fall study and analyzed for toxicant residue (Table 3). Results indicated a correlation between the rate of release or availability of chlordane and the nature of the chlordane formulation. A certain amount of species susceptibility was also noted.

Direct action of chlordane upon germinating seeds was studied by the use of petri dishes fitted with pre-treated filter paper. A series of progressive concentrations were employed and a critical level noted beyond which little, if any, normal germination or growth occurred. There was initial germination but the rudimentary root soon discolored, withered and died. The resulting seedlings remained stunted and died after exhaustion of stored food within the seed.

This investigation has demonstrated that seedbed applications of chlordane can result in decreased turf stand when administered at herbicidal rates. Therefore careful consideration must be given to the grasses planted and the formulation applied when treating seedbeds for crabgrass control.

ACKNOWLEDGMENT

Appreciation is extended to Dr. George K. Schumaker and the Velsicol Chemical Corporation for their aid and assistance in this investigation.

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[1]Contribution No. 1013. Rhode Island Agricultural Experiment Station.
[2]Former Graduate Assistant in Agronomy and Associate Agronomist respectively.

Table 1. Effects of Various Formulations and Rates of Chlordane on Turfgrass Stand When Applied as a Seedbed Treatment in the Fall.

Material	Lbs./1000 Sq. Ft.	Percent Stand, June 3, 1959* Astoria Col. Bent	Merion Ky. Blue	Ky. Blue	Chewings Fescue	Ave.
75% E. C.	0.5	89	88	74	75	82
40% W. P.	0.5	92	93	85	85	88
5% Verm.	0.5	88	87	81	80	84
5% Atta.	0.5	90	87	83	79	84
10% Atta.	0.5	91	88	78	85	85
	Ave.	90	89	80	81	84
75% E. C.	1.0	85	84	75	80	81
40% W. C.	1.0	91	89	85	86	87
5% Verm.	1.0	87	85	79	83	83
5% Atta.	1.0	86	81	83	85	83
10% Atta.	1.0	86	82	83	89	85
	Ave.	87	84	81	85	83
75% E. C.	2.0	63	40	40	74	54
40% W. P.	2.0	83	72	72	79	76
5% Verm.	2.0	85	73	55	74	71
5% Atta.	2.0	63	53	45	79	60
10% Atta.	2.0	75	68	60	72	69
	Ave.	74	61	54	76	66
No Treatment	---	90	93	85	83	87

*All figures represent averages of two replicates.

Table 2. Effects of Several Chlordane Formulations on Turfgrass Stands When Applied in the Spring.

		Percent Stand, May 19, 1960*				
Material	Lbs./1000 Sq. Ft.	Astoria Col. Bent	Merion Ky. Blue	Ky. Blue	Chewings Fescue	Ave.
75% E. C.	1.0	38	39	40	70	47
75% E. C.	1.5	20	20	20	50	28
75% E. C.	2.0	10	10	33	58	27
	Ave.	23	23	31	59	34
60% Vermic.	1.0	90	70	73	93	82
60% Vermic.	1.5	90	73	83	96	86
60% Vermic.	2.0	77	50	70	93	73
	Ave.	86	64	75	94	80
20% Vermic.	1.0	77	53	63	86	70
20% Vermic.	1.5	56	33	43	80	53
20% Vermic.	2.0	39	33	33	66	43
	Ave.	57	40	46	77	55
No Treatment	---	90	77	90	93	88

*Figures represent averages of three replicates.

Table 3. Analysis of Soil Residues[1]

Treatment	ppm of Chlordane
1. 40% Wettable powder:	
A. Kentucky bluegrass	2.4
B. Merion bluegrass	11.6
C. Chewings fescue	7.2
D. Astoria colonial bent	11.2
2. 75% Emulsifiable Concentrate:	
A. Kentucky bluegrass	6.4
B. Merion bluegrass	38.4
C. Chewings fescue	20.8
D. Astoria Colonial bent	17.6
3. 5% Vermiculite:	
A. Kentucky bluegrass	8.4
B. Merion bluegrass	28.4
C. Chewings fescue	33.6
D. Astoria Colonial bent	54.4
4. 5% Attaclay:	
A. Kentucky bluegrass	18.4
B. Merion bluegrass	40.8
C. Chewings fescue	36.0
D. Astoria colonial bent	28.0
5. 10% Attaclay:	
A. Kentucky bluegrass	54.4
B. Merion bluegrass	60.8
C. Chewings fescue	60.8
D. Astoria Colonial bent	92.8
6. Check	less than 1

[1]The method of determination was, with some necessary modifications, that presented by Ordas, E. P., Smith, V. C., and Meyer, C. F. in Agric. and Food Chem. 4 (5): 444. 1956.

THE EFFECT OF ZYTRON ON SEEDLING TURF GRASSES[1]

C. R. Skogley[2]

Spring seeded lawns are often beset with problems, chief among which may be competition with annual weed grasses. The elimination of this problem would solve an age old dilemma. Very recently several herbicides have been introduced that show promise of selectively controlling crabgrass when applied to established grasses prior to the germination of the crabgrass seed. Zytron, known chemically as 0-(2,4-dichlorophenyl) 0-methyl phosphoromidothioate, is one of these materials. Little is known about the value or use of this chemical with seedling grasses, however.

This test was established in order to preliminarily observe the effects of Zytron on seedling grasses under field conditions.

Materials and Methods

The test area was prepared and seeded on April 26, 1960. Eight different grasses were included, and were seeded in adjacent strips each 6 x 60 feet in size. The soil in the test area is classed as Bridgehampton silt loam and the pH was adjusted to about 6.5. Twenty pounds of an 8-6-2 fertilizer was applied per 1000 square feet and raked into the surface inch of soil prior to seeding. The grasses included in the trial were Kentucky bluegrass (*Poa pratensis*) and the Merion variety of Kentucky bluegrass, Creeping red and Chewings fescue (*Festuca rubra*), Kentucky 31 tall fescue (*Festuca arundinacea*), Perennial ryegrass (*Lolium perenne*), Redtop (*Agrostis alba*), and Astoria Colonia bentgrass (*Agrostis tenuis*). The seeding rate was 3 pounds per 1000 square feet for the bluegrasses, 6 pounds for the red fescues, 10 pounds for tall fescue and the ryegrass and 2 pounds for the *Agrostis* species. The *Agrostis* species were mowed at a height of one inch and all others were cut at 1½ inches.

Two formulations of Zytron were applied in two foot strips over each species of grass at 2, 4, 6, and 8 week intervals from the seeding date. Treatments were in triplicate and each interval was randomized within blocks. An emulsifiable concentrate (M-1329) containing 2 pounds active ingredient per gallon and a formulation on vermiculite (M-1662) containing 8% active material were employed at the rate of 20 pounds active per acre.

Periodic observations and readings were made to observe and record seedling and grass response to the treatments. Untreated controls were maintained as a standard for comparison. Plant counts were taken on one replication on July 5 - two weeks after the last chemical application. Estimates of turf coverage were made and root formation and penetration were studied in early November.

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[1]Contribution No. 1015 of the Rhode Island Agricultural Experiment Station.
[2]Associate Professor of Agronomy.

Results and Discussion

When the first Zytron treatments were made the bluegrasses had hardly commenced germination. The seedlings of the other species ranged in size up to about 2 inches with some seed still germinating. The soil was moist and cool and the grass growth was slow.

The emulsion spray applied two weeks after planting severely damaged or actually killed the seedlings of most species within a few days. The application of the dry formulation had little visual effect on the seedlings until several weeks after the application.

With each succeeding application the chemical treatment appeared less damaging to the grasses but at each interval the emulsion caused more rapid discoloration than the dry formulation. Table 1 gives the average number of grass plants present on July 5. These plant counts also indicate that the emulsion in general was more damaging than the dry formulation and that the earlier the date of treatment the greater the grass mortality.

The Agrostis species were most seriously injured with the earlier treatments. Of the bluegrasses the Merion variety appeared less tolerant of the chemical as did Chewings fescue when compared with creeping red fescue.

It was interesting to note that in most instances there were more plants present on those plots receiving treatment on the eighth week than on the untreated plots. Perhaps the treatment at the eighth week weakened the plants sufficiently to eliminate mortality usually occuring as a result of natural competition in dense turf stands.

The test area received only natural precipitation during the treatment period and at the 6 and 8 week intervals the soil was dry and the seedlings were making very slow growth. It is possible that this factor had an influence on the results indicated.

During August the test area was fertilized with an 8-6-2 fertilizer and water was supplied to insure an amount adequate for good grass growth. The recovery of the grass on many of the plots, even on many severely injured by early treatments, was of interest. The estimates of percentage turf cover taken on November 3rd would indicate this. Certain plots with no plants present on July 5 had as much as a 75 percent coverage in early November.

It is probable that a few seeds germinated after the plant counts were taken in July but most of the coverage was due to the spread of a few plants remaining in all plots even though the stand was so thin as to show a zero reading when quadrat counts were made. When the stands were thinned by chemical treatment the remaining plants became large and aggressive. This characteristic of the grasses appeared to eliminate much of the earlier differences attributed to formulation and application interval.

With very few exceptions, however, all treatments reduced the stands of grasses. In some instances the dry formulation gave lower coverage readings than the emulsion and in other instances the reverse was true. The late season estimates also indicate that treatment interval after seeding was not of great importance particularly with the dry formulation. The one exception was with redtop and colonial bent where the late emulsion treatments were less damaging than those applied at the first or second interval.

One very significant observation came to light when making the November readings. This observation may negate some of the data presented in table 2. It was found that those grasses spreading by stolons and those that tiller profusely, namely the Agrostis species and the red fescues, did not form normal roots as they increased in size. Those roots arising from nodes of the stolons and from the crowns as the plants enlarged would proliferate, thicken and remain short. Often an enlarged tip would result on contact with the soil. Few of these roots were able to penetrate into the soil. In some instances where roots appeared to develop normally they failed to enter the soil but grew laterally under the organic mat at the surface of the moist soil. Although the plants increased in size and gave the appearance of being normal they could readily be lifted from the soil. They were able to persist during the favorable fall growing season.

The same phenomenon was observed on a few crabgrass plants that had germinated prior to treatment in some of the plots. The roots formed prior to the chemical application appeared normal and were able to sustain growth of the plant but roots formed at the surface were malformed and failed to penetrate the soil.

The bluegrasses, spreading by rhizomes, did not appear adversely effected in their spread and no root abnormalities were observed. The tall fescue and ryegrass also appeared normal.

Summary and Conclusion

Eight grasses were seeded in normal prepared seedbeds and at standard rates on April 26, 1960. At intervals of 2, 4, 6, and 8 weeks after seeding an emulsifiable concentrate and vermiculate formulation of Zytron was applied to these grasses at the rate of 20 pounds of active material per acre. Periodic observations and stand counts were made during the growing season.

On the basis of the preliminary work the following conclusions have been drawn:

1. Seedling turf may be severely injured by Zytron application at the rate of 20 pounds per acre.

2. The emulsifiable concentrate of Zytron gave more immediate injury than did the dry formulation.

3. At the first treatment colonial bentgrass and redtop were most susceptible to injury followed by the bluegrasses, red fescues, tall fescue and perennial ryegrass in that order.

4. Immediate treatment injury to the turf decreased as the time interval increased following seeding.

5. There appeared to be little difference in end results between the use of an emulsion or a dry formulation with a few minor exceptions.

6. Normal root growth may be prevented on those seedling grasses spreading by stolons or by tillering following the application of either formulation of Zytron. Those grasses spreading by rhizomes appear to make normal growth in soils treated with this chemical.

7. The application of Zytron at the rate of 20 pounds per acre to seedling turf, within a period of 2 to 8 weeks after planting, could result in a stand reduction or in weakened turf.

Acknowledgment

The Author expresses appreciation to the Dow Chemical Company, Midland, Michigan, for assistance in making this study possible.

Table I. Average number of grass plants per square inch on July 5, 1960, following the application of two formulations of Zytron at several intervals after seeding on April 26, 1960.

Grass	Formulation	Treatment Interval Following Seeding: 2 Wks.	4 Wks.	6 Wks.	8 Wks.	Ave. of Intervals	Check
		Ave. No. of Plants Per Square Inch					
Merion Ky. Blue	Emulsion	0.0	3.8	5.2	18.2	6.8	9.8
	Vermiculite	1.2	10.2	2.2	24.0	9.4	
Kentucky Blue	Emulsion	0.2	1.0	5.8	11.0	4.5	11.4
	Vermiculite	1.2	11.8	11.0	8.5	8.1	
Chewings Fescue	Emulsion	0.2	3.5	6.0	7.5	4.3	10.1
	Vermiculite	6.5	6.0	7.2	11.5	7.8	
Creeping Red Fescue	Emulsion	0.8	1.0	5.5	8.0	3.8	11.4
	Vermiculite	5.8	18.5	6.5	15.0	11.4	
Tall Fescue (Kentucky 31)	Emulsion	2.0	2.0	1.8	3.8	2.4	5.9
	Vermiculite	1.2	2.0	4.0	6.8	3.5	
Per. Ryegrass	Emulsion	2.8	3.5	4.0	6.5	4.2	6.1
	Vermiculite	4.0	5.0	7.2	9.0	6.3	
Redtop	Emulsion	0.0	0.5	10.0	18.2	7.2	13.0
	Vermiculite	3.5	5.5	10.2	18.0	9.3	
Colonial Bent (Astoria)	Emulsion	0.0	0.0	0.0	20.0	5.0	18.6
	Vermiculite	0.5	2.0	12.2	24.2	9.7	
Ave. All Grasses	Emulsion	0.8	1.9	4.8	11.6	4.8	10.9
	Vermiculite	3.0	7.6	7.6	14.6	8.2	

Table II. Estimated Percentage of Turf Cover - Six Months After Seeding and Four Months After The Last Zytron Treatment.

Grass	Formulation	2 Wks.	4 Wks.	6 Wks.	8 Wks.	Ave. of Interval	Check
		Treatment Interval Following Seeding					
		Estimated Percentage of Ground Cover					
Merion Ky. Blue	Emulsion	75	70	60	90	74	100
	Vermiculite	95	100	50	40	71	
Kentucky Blue	Emulsion	75	90	50	85	75	100
	Vermiculite	90	100	75	80	86	
Chewings Fescue	Emulsion	80	60	55	85	70	100
	Vermiculite	90	60	50	35	59	
Creeping Red Fescue	Emulsion	90	85	85	95	89	95
	Vermiculite	95	95	85	85	90	
Tall Fescue (Kentucky 31)	Emulsion	90	90	85	90	89	100
	Vermiculite	95	100	95	100	98	
Per. Ryegrass	Emulsion	90	80	85	90	86	100
	Vermiculite	90	90	90	95	91	
Redtop	Emulsion	40	50	75	80	61	100
	Vermiculite	90	70	90	85	84	
Colonial Bent (Astoria)	Emulsion	10	70	50	85	54	100
	Vermiculite	100	60	90	80	82	
Ave. All Grasses	Emulsion	69	75	68	88	75	99
	Vermiculite	93	84	78	75	83	

Experiments in Pre-emergence Crabgrass Control

by R. G. Mower and J. F. Cornman*

During the 1959 growing season a number of chemicals gave very promising results for pre-emergence crabgrass control both in our own experimental work (1) and in experimental work at other stations. This paper reports the continuation of trials with the more promising of these pre-emergence chemicals. Both fall and spring treatments were made with a variety of chemicals. A third set of plots included only Dacthal and a commercial formulation of it at increasing rates to observe possible turf injury effects.

Crabgrass control by various chemicals

Materials and methods

The experimental area was located at the Cornell Turf Research Plots, Nassau County Park, East Hempstead, Long Island. The treated turf was much like that used in previous trials (1), consisting of a good stand of mixed Kentucky bluegrass and red fescue with a scattering of volunteer bentgrass and clover. The turf was maintained at about 1½ inch height, well fertilized, and adequately irrigated. During the 1959 season this area, like the untreated areas of the 1959 plots, was rather uniformly and heavily (60%) infested with crabgrass.

The pre-emergence chemicals were applied at two seasons. Fall treatments were made on November 13, 1959 and the spring treatments on March 31, 1960. The experimental design for both the fall and spring treatments was a complete randomized block with treatments in triplicate on 7 x 7' plots. Serving as checks in the fall treatments were seven plots, and in the spring treatments eight plots. Dry formulations were broadcast by hand without diluent. The liquid formulations and wettable powders were applied with a sprinkling can in water at the rate of about 10 gallons per 1,000 sq. ft.

Results and discussion

Crabgrass control

The growing season of 1960 on Long Island was not a "good crabgrass year," especially in the dense stand of vigorous turf on our plots. As a result it was impossible to make crabgrass control estimates in terms of proportion of the area covered. To have any record at all of the results it was necessary to count individual plants. These counts are shown in Tables 1 and 2. While the average counts for the check plots seem large at first glance, it should be noted that almost all of the plants in all of the plots were very small and much crowded by the vigorous competing turf. Hence even in the most badly infested checks the total area occupied by crabgrass was scarcely more than 1 or 2 per cent of the plot area. The differences in counts between treatments and between treatments and checks again is superficially large, but the variations among the replicates was great enough so that, upon statistical analysis, it appears that these superficial differences

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have very little real meaning as far as crabgrass control is concerned. About all that can be concluded is that most of the treatments controlled crabgrass, at least at the 5 per cent level of significance, but no real differences were demonstrated between the degrees of control resulting from the different treatments. Previously it seemed that making crabgrass control applications on high quality turf had particular value because of its similarity to the usual turf to which such chemicals might be applied. Apparently the practice of thinning heavy turf and seeding in crabgrass deliberately has real merit as insurance against the possibility of climatic conditions particularly unfavorable to crabgrass.

Turf injury

In reporting on our 1959 plots (1) we noted that there was no turf injury from the crabgrass control chemicals except for Dacthal, which severely injured red fescue.

Our first opportunity to work with Zytron was in our spring 1959 plots. In those trials we noted no turf injury from the use of granular Zytron at the rate of 20 pounds active ingredient per acre. As noted in Tables 1 and 2, this same 20 pound ("standard") rate of granular Zytron caused some temporary discoloration of both fescue and bent in the fall 1959 plots and a little, but considerably less, discoloration from the spring 1960 treatments. The 40 pound rate of granular Zytron as well as the 20 and 40 pound rates of Zytron emulsion caused severe turf injury in the fall treatments and the 20 pound rate (the only one included) in the spring treatments also caused severe but somewhat less turf injury.

The Dacthal wettable powder was available for use in both our fall 1958 and spring 1959 treatments. While it produced excellent crabgrass control at the rate of 12 pounds active ingredient per acre, it caused severe injury to red fescue in both fall and spring (1). The same material applied at the same rate in the fall of 1959 and the spring of 1960 caused rather conspicuous temporary discoloration of red fescue and bent in the autumn plots but very slight discoloration in a single replicate of the spring plots. A new granular formulation of Dacthal, first available in the spring of 1960, caused no discoloration at that time. Rid, the commercial formulation of Dacthal, was available in the spring of 1960 only. At the recommended rates of application, it caused no visible turf injury.

In the 1959 work Dacthal caused marked injury to red fescue. To investigate the Dacthal injury further, unreplicated 48. sq. ft. plots were laid out on a predominantly red fescue turf. Dacthal wettable powder and Rid, a granular commercial formulation of Dacthal, were applied at rates of 6, 10, 12, and 18 pounds active ingredient per acre on March 1 and May 2, 1960. The crabgrass counts appear in Table 3.

It is interesting to note that while crabgrass control was essentially complete on all plots except where the 6 pound rate of Rid was used, there was no visible turf discoloration at any time. These observations are in line with the performance of the same materials in the other spring 1960 applications reported in Table 2. The implication from the 1960 plots alone is that Dacthal caused little or no turf injury. Yet the same material in the spring of 1959 did cause severe injury. Apparently the degree of fescue injury from Dacthal is influenced by factors in addition to season of application.

In summary, the observations reported here suggest that both Dacthal and Zytron may, at least under some conditions, cause injury to red fescue and bent. No injury to bluegrass was noted. In all instances on these plots the treated areas recovered to about the same turf density as before, though with a decrease in fescue population and a compensating increase in bentgrass and other perennial grasses.

Literature Cited

1. Mower, R. G., and J. F. Cornman. Pre-emergence and post-emergence crabgrass control. Proc. N.E. Weed Control Conf. 14: 271-277. 1960.

Table 1. Pre-emergence crabgrass control. Cornell-Nassau County Turf Plots. Results of fall treatments

Treatment	Rate	Average crabgrass plants/plot	% control	Injury ratings
1. Lead arsenate	20#/M	4.0	86	1,0,0
2. Calcium arsenate gran.	12#/M	8.3	70	0
3. "Pax" (proprietary arsenical)	25#/M	3.7	87	1,1,0
4. Chlordane 72% emulsion	60# a.i./A	6.3	76	1,0,0
5. " 10% granular	60# a.i./A	13.7	51	0
6. " 60% "	60# a.i./A	4.3	85	0
7. "Halts" (proprietary Chlordane gran.)	6#/M	3.3	88	0
8. Dacthal (DAC-893) 50% w.p.	12# a.i./A	4.0	86	2+,2
9. Zytron (Dow 1481) gran.	20# a.i./A	1.0	96	2,1,1
10. " " "	40# a.i./A	0.0	100	3+,2+,2
11. " (Dow 1329) emul.	20# a.i./A	0.3	99	3,3,2
12. " " "	40# a.i./A	0.0	100	3+,3+,3+
13. Checks		28.1		
LSD_{05}		21.9	78	
LSD_{01}		29.5		

Herbicide applications: Nov. 13, 1959 Injury ratings: May 1, 1960
Crabgrass counts: Oct. 29, 1960

Turf injury ratings: 1 - slight, 2 - moderate, 3 - severe, 4 - complete kill

Table 2. Pre-emergence crabgrass control. Cornell-Nassau County Turf Plots. Results of spring treatments.

Treatment	Rate	Average crabgrass plants/plot	% control	Injury ratings
1. Lead arsenate	20#/M	6.0	92	0
2. Calcium arsenate gran.	12#/M	12.0	84	1,0,0
3. "Pax" (proprietary arsenical)	25#/M	22.3	71	0
4. Chlordane emulsion	60# a.i./A	15.7	79	0
5. " "	80# a.i./A	2.0	97	0
6. Chlordane 10% granular	80# a.i./A	8.3	89	0
7. "Halts" (proprietary Chlordane gran.)	6#/M	16.3	79	0
8. Dacthal (DAC-893) 50% w.p.	12# a.e./A	7.7	90	1,0,0
9. " " granular	12# a.e./A	0.7	99	0
10. "Rid" (proprietary Dacthal gran.)	10#/M	16.0	79	0
11. Zytron (Dow 1481) gran.	20# a.i./A	8.0	90	1,0,0
12. " (Dow 1329) emul.	20# a.i./A	2.7	96	2,2+,2
13. Check		58.9		
LSD_{05}		40.9	69	
LSD_{01}		55.0		

Herbicide applications: March 31, 1960. Injury ratings: May 1, 1960
Crabgrass counts: October 29, 1960

Turf injury ratings: 1 - slight; 2 - moderate; 3 - severe; 4 - complete kill

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Table 3. Pre-emergence crabgrass control with spring 1960 applications of increasing amounts of Dacthal.

Rate lbs. a.i./A	Crabgrass plants/48 sq. ft. — Dacthal w.p. — Application date 4/1	Dacthal w.p. 5/2	"Rid" 4/1	"Rid" 5/2
6	0	1	0	6
10	0	0	1	0
12	0	0	0	0
18	0	0	0	1
Checks	26		26	

Turf injury: none

The Effect of Preemergence Chemicals on Crabgrass and Bluegrass, Fescue and Bentgrass Turf.

J.M. Duich, B.R. Fleming and A.E. Dudeck [1]

The object of this study was to determine the effect of several chemicals on three major turfgrass species and their value in preemergence crabgrass control.

Materials and Methods

Four individual field test areas were involved and their turf populations were as follows:

1. Pennlawn Cr. Red Fescue - 4 year stand
2. Merion Kentucky Bluegrass - 4 year stand
3. Highland-Astoria bent mixture - 4 year stand
4. Common Kentucky bluegrass - 8 year stand

Turf was maintained at 1½" without supplementary irrigation. Rainfall data are shown in Table 1. The turf received 2½ lbs. of natural organic nitrogen in two applications, except for the Merion bluegrass which received 4 lbs.

Individual test plots were 6' x 10' in a split plot design with three replications. Dry materials were applied by hand following mechanical dilution with 9 quarts of screened soil. Emulsions were applied with a 6 foot boom plot sprayer at 35 psi with 90 gallons of water per acre.

Identical treatments were applied to test areas 1, 2 and 3 at two rates on May 5, 1960. Materials and rates as shown in Tables 2, 3 and 4. These respective materials were applied on area 4, but only at the lower rate on April 14, May 2 and May 17. All treatment plots received a single application.

Discoloration and/or injury data on turf species were recorded at 1-2 week intervals throughout the growing season on a 0 to 10 scale (0 = effect), and final record on basis of percent density reduction. Crabgrass survival and final turf injury were recorded on October 10. Crabgrass counts were made by cutting out plants in 10 one-square-foot quadrates per plot. Turf injury estimates were made by two or three observers.

Crabgrass (Digitaria sp.) seedling emergence was first noted on May 27, however the greatest germination occurred after June 4. The germination range dates on "open" turf areas for University Park, based on previous 6-year data, are May 13-22.

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Table 1. 1960 Rainfall and Temperature
University Park, Pa.

	Week Ending	Inches Rainfall	Temperature Max.	Min.		Week Ending	Inches Rainfall	Temperature Max.	Min.
May	9	1.96	78	34	August	1	0.13	80	57
	16	1.40	74	36		8	0.96	86	56
	23	2.42	82	48		15	0.01	83	55
	30	0.83	77	44		22	0.07	83	50
June	6	0.79	88	52	Sept.	5	0.96	89	49
	13	0.45	83	44		12	3.01	86	54
	20	1.17	87	55		19	0.82	76	44
	27	0.15	83	54		26	0.38	75	46
July	4	1.26	85	56	Oct.	3	0.27	74	38
	11	0.30	85	49		10	0.35	68	36
	18	1.58	85	46					
	25	0.29	85	54					

Results and Discussion

Turf Tolerance. Discoloration and/or injury data on areas 1, 2 and 3 (red fescue, Merion bluegrass and colonial bent, respectively) are shown in Tables 2, 3 and 4, respectively. No data are shown for area 4, common Kentucky bluegrass, due to absence of any visible injury from the treatments applied.

Granular chlordane and the commercial Halts formulations showed no detrimental effects, however, the Ortho emulsion resulted in instant discoloration. The effects of the 120 rate persisted for 12 weeks on the Merion and bent, and for five months on the fescue. A slight thinning and chlorosis was noted on the fescue.

All Dacthal formulations were severe in both discoloration and injury on the fescue and bent, but showed no toxicity on Merion bluegrass. Initial discoloration showed approximately 17 days following applications. The plots received 0.3 inches of rain three days following application, and 7.17 inches in 17 of the 23 remaining days in May. The Granular form was more toxic than the W-50 or Rid in both discoloration and turf reduction. Greater turf reduction occurred on the fescue, but this was believed due to its slower recovery growth during the fall months compared to the bent.

Granular Zytron, M-1662, was similar to the Dacthal formulations in its effects on the various turf species. It was nontoxic to Merion and showed the same injury pattern on fescue and bent. The emulsion, M-1329, discolored fescue, Merion and bent immediately following application. The Merion remained discolored for approximately 10 weeks and showed no permanent injury. Fescue and bent remainded discolored by the M-1329 all season and were moderately thinned. As for the M-1662 and Dacthal formulations the fescue showed more permanent injury than the bent by October.

The calcium arsenate treatments affected only the fescue and bent. The discoloration showed as a bluish wilted appearance in contrast to a browning effect from Dacthal and Zytron. Injured plots also resulted in retarded growth. Fescue was only slightly thinned out whereas the colonial bent showed moderate thinning. There were practically no differences in injury between the two rates of calcium arsenate, whereas all other injurious treatments showed very significant differences for the two rates used in this study.

Crabgrass Control. Results of preemergence crabgrass control are shown in Table 5 both as plant survival per square foot and percent reduction based on six control plots. Control plots averaged 20 plants with a range of 14 to 29 plants per sq. ft. Crabgrass data are shown only for test area 1 (fescue) due to best uniformity of stand.

Granular chlordane proved to be the most effective chlordane formulation and gave 99 percent control at the 120 lb. rate. The 60 lb. rate of the granular and emulsion and Halts at the recommended 6 lbs/M were not satisfactory based on plant survival.

Dacthal, Zytron and calcium arsenate treatments gave 97 to 100 percent control except for the Zytron M-1329 at the lower 13 lb. rate (93% control). Although the control range variable was small, crabgrass control appeared correlated with turf injury between the Dacthal and Zytron formulations, respectively. This suggests the possibility of variation in active ingredient per formulation as applied in this study.

Results showed the lower rates of the above three materials to be at or near their most efficient level for crabgrass control. Observations on the other test areas showed similar material treatment effects on crabgrass germination.

Other Observations. Test area 4, common Kentucky bluegrass, was selected due to a heavy crabgrass infestation during the 1959 season. However, in 1960, it changed from crabgrass to a knotweed economy. Knotweed was in the 2-leaf stage at the time of the first treatment, April 14.

Zytron was the only material to exhibit post-emergence control. M-1329, emulsion, at 13 lbs. per acre resulted in nearly 100 percent control for the three treatment dates April 14, May 2 and May 17. Granular M-1662 resulted in 60-80 percent control, with better control at the earlier date.

Calcium arsenate weakened *Poa annua* to the point where it was killed during the first moisture and high temperature stress period in July.

Conclusions

Chlordane, except for certain emulsion formulations, was nontoxic to bluegrass, fescue and bent turf.

Chlordane must be used at rates in excess of 60 lbs. a.i./acre for satisfactory crabgrass control. This study showed granular chlordane as the most effective formulation.

Dacthal was nontoxic to common and Merion bluegrass, but significantly reduced the density of Pennlawn fescue and colonial bent.

Dacthal formulations were very effective for preemergence crabgrass control.

Zytron emulsions, M-1329, will temporary discolor Merion bluegrass and reduce the density of Pennlawn fescue and colonial bent.

Zytron, M-1662, reacted similarly to Dacthal, but was not as severe on Pennlawn fescue and colonial bent density at the rates used in this study.

Zytron formulations are very effective for preemergence crabgrass control.

Calcium arsenate discolored and inhibited growth of Pennlawn fescue and colonial bent, but was not too severe on reducing their density. It was nontoxic to common and Merion bluegrass and resulted in satisfactory crabgrass control.

Table 2. Effect of preemergence materials on Pennlawn creeping red fescue expressed as discoloration and/or injury and percent density reduction. Materials applied on May 5, 1960.

Material	Rate	Discoloration and/or Injury (0 to 10)						% Density Reduction
		May 9	May 20	May 27	June 3	June 16	July 5	October 10
Dac (Rid)	10/M	0	0	1	3	3	5	47
	20/M	0	0	1	3	4	7	75
Dac W-50	10 a.i./A	0	0	2	4	6	5	43
	20 a.i./A	0	0	3	5	7	8	77
Dac G-1½	10 a.i./A	0	0	2	4	6	6	63
	20 a.i./A	0	0	4	6	7	8	82
Chlordane (Halts)	6/M	0	0	0	0	0	0	0
	12/M	0	0	0	0	0	0	0
Chlordane 72 EC (Ortho)	60 a.i./A	4	5	5	4	1	0	3
	120 a.i./A	5	7	7	6	3	2	7*
Chlordane G-10	60 a.i./A	0	0	0	0	0	0	0
	120 a.i./A	0	0	0	0	0	0	0
Zytron M-1662	13 a.i./A	0	0	2	4	5	4	17
	26 a.i./A	0	0	4	5	6	6	53
Zytron M-1329	13 a.i./A	4	4	5	5	4	3	13
	26 a.i./A	5	6	7	7	6	6	23
Ca. Arsenate G-73	19/M	0	1	2	4	5	3	5**
	38/M	0	1	2	4	5	3	5**
Control	-	0	0	0	0	0	0	0

* Slight chlorosis - 10/10/60
** Retarded growth - 10/10/60

Table 3. Effect of preemergence materials on Merion bluegrass expressed as discoloration and/or injury and percent density reduction. Materials applied on May 5, 1960.

Material	Rate	Discoloration and/or Injury (0 to 10) May 9	May 20	May 27	June 3	June 16	July 5	% Density Reduction October 10
Dac (Rid)	10/M	0	0	0	0	0	0	0
	20/M	0	0	0	0	0	0	0
Dac W-50	10 a.i./A	0	0	0	0	0	0	0
	20 a.i./A	0	0	0	0	0	0	0
Dac G-1½	10 a.i./A	0	0	0	0	0	0	0
	20 a.i./A	0	0	0	0	0	0	0
Chlordane (Halts)	6/M	0	0	0	0	0	0	0
	12/M	0	0	0	0	0	0	0
Chlordane 72 EC (Ortho)	60 a.i./A	3	5	4	4	2	1	0
	120 a.i./A	6	7	6	6	4	3	0
Chlordane G-10	60 a.i./A	0	0	0	0	0	0	0
	120 a.i./A	0	0	0	0	0	0	0
Zytron M-1662	13 a.i./A	0	0	0	0	0	0	0
	26 a.i./A	0	0	0	0	0	0	0
Zytron M-1329	13 a.i./A	4	4	6	4	2	1	0
	26 a.i./A	5	6	3	6	4	2	0
Ca. Arsenate G-73	19/M	0	0	0	0	0	0	0
	38/M	0	0	0	0	0	0	0
Control	-	0	0	0	0	0	0	0

Table 4. Effect of preemergence materials on colonial bent expressed as discoloration and/or injury and percent density reduction. Materials applied on May 5, 1960.

Material	Rate	May 9	May 20	May 27	June 3	June 16	July 5	% Density Reduction October 10
		Discoloration and/or Injury (0 to 10)						
Dac (Rid)	10/M	0	0	1	4	5	5	17
	20/M	0	0	2	4	7	7	37
Dac W-50	10 a.i./A	0	0	2	4	6	6	25
	20 a.i./A	0	0	3	6	8	8	58
Dac G-1½	10 a.i./A	0	0	2	4	6	7	30
	20 a.i./A	0	0	3	6	8	8	45
Chlordane (Halts)	6/M	0	0	0	0	0	0	0
	12/M	0	0	0	0	0	0	0
Chlordane 72 EC (Ortho)	60 a.i./A	3	4	4	3	2	1	0
	120 a.i./A	4	6	6	5	4	1	0
Chlordane G-10	60 a.i./A	0	0	0	0	0	0	0
	120 a.i./A	0	0	0	0	0	0	0
Zytron M-1662	13 a.i./A	0	0	2	4	5	5	13
	26 a.i./A	0	0	3	5	7	8	37
Zytron M-1329	13 a.i./A	2	5	5	5	5	3	7
	26 a.i./A	3	7	8	8	8	5	17
Ca. Arsenate G-73	19/M	0	0	2	3	4	2	12*
	38/M	0	0	2	3	5	3	13*
Control	-	0	0	0	0	0	0	0

* Retarded growth - 10/10/60

Table 5. Effect of preemergence materials on crabgrass control expressed as average plants survival per square foot and percent reduction based on control plots. Treatments applied May 5, 1960; data recorded October 10, 1960.

Material	Rate	Crabgrass (Digitaria sp.) Ave. Plants/Sq.Ft.*	% Reduction**
Dac G-1½	10 a.i./A	0	100
	20 a.i./A	0	100
Dac W 50	10 a.i./A	0.1	99.5
	20 a.i./A	0	100
Dac (Rid)	10/M	0.6	97
	20/M	0.4	98
Chlordane G-10	60 a.i./A	4.0	80
	120 a.i./A	0.2	99
Chlordane 72 EC (Ortho)	60 a.i./A	9.7	51.5
	120 a.i./A	2.2	89
Chlordane (Halts)	6/M	6.7	66.5
	12/M	3.8	81
Zytron M-1329	13 a.i./A	1.4	93
	26 a.i./A	0.2	99
Zytron M-1662	13 a.i./A	0.5	97.5
	26 a.i./A	0.1	99.5
Ca. Arsenate G-73	19/M	0.6	97
	38/M	0.4	98
Control	-	20.0	-

* Ave. 10 Sq.Ft. quadrate counts per plots, 3 replications

** % reduction based on 6 control plots

COMPARISONS OF PRE-EMERGENCE HERBICIDES FOR THE CONTROL OF CRABGRASS[1]

John F. Ahrens and A. R. Olson[2]

Homeowner interest in chemicals for the control of crabgrass in turf has increased greatly over the past few years. Public requests for information on this subject have correspondingly increased. To fill the need for more information in this area tests were started in 1960 with several pre-emergence herbicides.

Procedure

A series of plots were set up on established turf at the Station grounds in New Haven, at Mt. Carmel, and in South Windsor. Plots were at least 4 feet wide and 12 feet long. Alternate plots remained untreated. The number of replications varied from 3 to 5, depending on the treatment.

The materials used were as follows:

a) Zytron, 8% granular formulation on vermiculite
b) Dacthal, 1.5% granular formulation
c) "Halts," a material composed of 23% chlordane on vermiculite
d) "Bonide chlordane," containing 72% chlordane as emulsifiable concentrate
e) "Pax," a material containing 25.11% arsenous oxide, 8.25% arsenate of lead, 0.34% heptachlor, and 8.0% ammonium sulfate
f) "No Crab," a material containing 47.22% calcium arsenate, 0.38% 2,4-D, and 0.13% silvex

The dry formulations were applied with a 2-foot lawn spreader, calibrated for each material. The liquid formulation of chlordane was applied in 390 gallons of solution per acre with a watering can.

Most treatments were applied on April 28 and 29, before any crabgrass had emerged. However, calcium arsenate and one dosage of chlordane were applied on May 17, when crabgrass was emerging in some plots. In one area, half of each plot was watered after treatment.

The established turf consisted of a mixture of Kentucky bluegrass, fescue grasses and bentgrass. To encourage crabgrass invasion, these areas were mowed to a height of 3/4 to 1 inch in May and June, and slightly higher thereafter. The plots were fertilized in early spring according to soil tests.

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1. Contribution of The Connecticut Agricultural Experiment Station, New Haven, Connecticut.

2. Assistant Plant Physiologist and Assistant Forester, respectively.

In one area, the old turf was roto-tilled, a new seeding was established, and the treatments were applied immediately after seeding. The seed mixture included 49% Chewings fescue, 21% Kentucky bluegrass, 15% annual ryegrass, and 10% colonial bentgrass.

Crabgrass stands were estimated visually in all plots by three persons, and by counts of crabgrass plants per square foot.

Results

Newly seeded turf

The treatments on newly seeded turf included dry formulations of chlordane at 60 lbs./A., "Pax" at 784 lbs./A., calcium arsenate at 370 lbs./A., zytron at 10 and 20 lbs./A., and dacthal at 7.5 and 10 lbs./A. All of these treatments were unsatisfactory. The chlordane and "Pax" did not appear to affect the turf grasses but crabgrass control was so poor that the turf grasses soon were smothered. Dacthal and zytron, on the other hand, controlled the crabgrass but severely injured the turf grasses. In the fall, however, the best stands of turf were on plots treated with zytron at 20 lbs./A. or dacthal at 10 lbs./A. Chewings fescue and ryegrass were in greatest abundance in these plots but covered only 20 to 30% of the area. With the early post-emergence application of calcium arsenate, both turf kill and poor control of crabgrass was obtained.

Established turf

With favorable weather conditions and close mowing, excellent stands of crabgrass were obtained in the experimental areas. The results of one test are shown in Table 1. These results are typical of those obtained in the other areas.

Zytron at 20 lbs./A. and dacthal at 7.5 or 10 lbs./A. provided excellent seasonal control of crabgrass. Zytron at 10 lbs./A. also was very satisfactory. In data not shown, slightly better control was evident where zytron and dacthal were watered in following application. Neither of these materials injured the turf and zytron plots appeared slightly greener than other plots late in the season. In other tests, bentgrass turf (variety C1-C19) appeared to be tolerant of zytron at 30 lbs./A. and dacthal at 15 lbs./A.

Although the calcium arsenate was applied when some crabgrass was emerging, it also provided excellent seasonal control. In another area where crabgrass was slightly further along, however, poor control of crabgrass resulted. At a dosage of 555 lbs./A., 1-1/2 times the amount suggested on the bag of "No Crab," the calcium arsenate complex thinned the Kentucky bluegrass. This injury was less evident late in the season.

Chlordane, both in dry form as shown in Table 1, and as the emulsifiable concentrate, failed to control satisfactorily the dense stands of crabgrass which invaded the plot areas. Crabgrass control ranged from 40 to 80% for the season, and appeared to be somewhat better in areas watered immediately

Table 1. Crabgrass Control with Pre-emergence Herbicides

Herbicide	Rate active ingred., lbs./A.	July 1		Sept. 20	
		% Control[1]	Crabgrass plants per sq.ft.[2]	% Control[1]	Crabgrass plants per sq.ft.[2]
Controls	-	0	1,790	0	890
Zytron	10	96	32	87	7
	20	99+	.02	99+	.03
Dacthal	7.5	99+	.3	95	3
	10	99+	.35	98	.3
Calcium arsenate[3]	370	92	8.7	95	2.7
	555	98	35	100	0
Chlordane	60	77	82	60	267
	120[3]	66	85	53	81
"Pax"	784[4]	77	103	36	241

1. Percentage control based on visual estimates of area covered by crabgrass in treated and untreated plots.

2. Average of 8 to 12 samples taken in each plot.

3. Applied May 17; all others applied April 29, before crabgrass emergence.

4. Rate of "Pax" per acre.

following application. The high dosage of 120 lbs. of actual chlordane per acre, applied early post-emergence, did not injure the established turf, although, as expected, poor control of crabgrass resulted.

"Pax" caused an early flush of growth due to the fertilizer ingredient but also failed to control crabgrass satisfactorily. It must be noted that due to a calibration error, "Pax" was applied at approximately 87 lbs./A. less than the dosage suggested on the bag. This represents an 11% error which could have affected the results. Watering following application did not appear to influence the results. The turf grasses appeared unaffected by "Pax."

Summary

Preliminary trials were conducted with several pre-emergence herbicides to control crabgrass in turf. Under the conditions of these experiments none of the materials, including chlordane, "Pax," zytron, dacthal or calcium arsenate, was satisfactory for immediate use on a mid-spring seeding of turf grasses. On established turf, however, zytron, dacthal and calcium arsenate provided better than 95% control of crabgrass without injuring the turf. Chlordane and "Pax" failed to control crabgrass satisfactorily.

PRE-EMERGENCE CRABGRASS CONTROL ON TURFGRASS

R. E. Engel, R. D. Ilnicki and R. N. Cook[1]

Good pre-emergence crabgrass control has been given by calcium arsenate, chlordane, dacthal, and zytron for one or more seasons at New Brunswick, New Jersey. Promise with these chemicals has encouraged additional study at this station and other locations in the state. This report gives 1960 results with these and four additional herbicides. Maximum level of performance obtained and best results for three different dates of spring application are given.

Materials and Procedure

Calcium arsenate, chlordane, dacthal (dimethyl 2,3,5,6-tetrachloroterephthalate), L-13489 (diphenylacetonitrile), L-31864 (N,N-di(n-propyl)-2,6-dinitroaniline), lead arsenate, an arsenical complex (Pax), and zytron (O-(2,4-dichlorophenyl) -O-methyl isopropylphosphoramidothioate) were used for pre-emergence crabgrass control. Calcium arsenate (73%), lead arsenate, and the arsenical complex were applied in their standard form. Zytron was applied with a vermiculite carrier. Chlordane, dacthal, L-13489, and L-31864 were formulated with granular clay.

With the exception of lead arsenate (hand applied), treatments were made with a 3-foot lawn fertilizer spreader. Plots were 3 x 20 feet and each treatment was in triplicate.

The test was conducted on lawn turf which was predominatly Kentucky bluegrass. The turf area was overseeded with crabgrass seed in the fall of 1959 and received a moderate application of natural organic fertilizer. The stand of crabgrass developed slowly because of insufficient rainfall in late spring. However, the turfgrasses never experienced severe heat or drought during the remainder of the season.

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The standard date of application was March 22, 1960. Additional treatments with calcium arsenate, chlordane, dacthal, L-13489, and Zytron were applied in early April and early May to determine the importance of timing.

Crabgrass control and turfgrass injury were determined by averaging estimates of three individuals. The following scale was used for turfgrass injury: 0-none, 1-slight, 2-moderate, 3-severe, and 4-very severe - complete kill.

Results and Discussion

The best performances of the eight pre-emergence herbicides gave crabgrass control ratings that ranged from 29 to 96% (table 1). Calcium arsenate, dacthal, and L-31864 effected 96% control with 80 and 84% control obtained for zytron and chlordane, respectively.

The arsenical complex and the calcium arsenate treatment rated a slight and moderate injury, respectively. The injury ratings for the other treatments were lower and can be considere negligible.

The highest crabgrass control ratings were obtained with the early spring treatments (March) of chlordane and dacthal (table 2). Calcium arsenate gave equally good control ratings with the March and April treatments which were far more efficient than May treatment. Also, injury ratings with this chemical increased with the delay of treatment. Treatment with L-13489 and zytron in May appeared no less effective than earlier treatments.

Summary and Conclusions

Pre-emergence treatments for crabgrass control were made with calcium arsenate, chlordane, dacthal, L-13489, L-31864, lead arsenate, an arsenical complex (Pax), and zytron on a predominately Kentucky bluegrass turf. Crabgrass started slowly and very little turfgrass failed during the season.

Estimates of crabgrass control made in September by three independent observers showed ratings of 96% obtained with calcium arsenate, dacthal, and L-31864. Zytron and chlordane produced 89 and 84% control, respectively. Ratings for turfgrass injury showed slight to moderate injury for the arsenical complex and calcium arsenate.

Early spring applications appeared advantageous for calcium arsenate, chlordane, and dacthal. L-13489 and zytron appeared to perform as well with May applications as with March and April applications.

Table 1. Performance of eight pre-emergence crabgrass herbicides on Kentucky bluegrass turf.

Chemical	Rate/A	Per cent Control	Turfgrass Injury[1]
Calcium arsenate	784	96	1.5
Chlordane	120	84	0.3
Dacthal	12	96	0.0
L-13489	45	62	0.2
L-31864	20	96	1.1
Lead arsenate	1089	29	0.2
Arsenical complex (Pax)	1089	35	0.9
Zytron[2]	20	89	0.1

[1]0 = none, 1 = slight, 2 = moderate, 3 = severe, 4 = very severe to kill.

[2]Applied May 3, 1960. All others applied March 22, except L-13489 and L-31864 which were applied March 28.

Table 2. Effect of season of applying pre-emergence herbicides on crabgrass control in Kentucky bluegrass turf. New Brunswick, N. J.

Chemical	Date of Treatment	Rate of Applic./A.	Per cent Control	Injury Rating
Calcium arsenate	3-22	523	94	0.6
"	4-12	"	94	1.0
"	5-3	"	65	1.6
"				
Av.			84	
Chlordane	3-22	80	60	0
"	4-12	"	50	0
"	5-3	"	53	0
"				
Av.			54	
Dacthal	3-22	12	95	0.2
"	4-12	"	88	0.2
"	5-3	"	65	0
"				
Av.			89	
L-13489	3-28	30	41	0
"	4-12	"	39	0.3
"	5-3	"	48	0.2
"				
Av.			43	
Zytron	3-22	20	86	0.1
"	4-12	"	82	0
"	5-3	"	89	0.1
"				
Av.			86	

PRE-EMERGENCE CONTROL OF CRABGRASS IN LAWN TURF[1]

E. J. Rice and C. R. Skogley[2]

There is a perennial search for chemicals which will control crabgrass in established turfgrass areas. This quest has an inherent problem of selectivity; to kill the crabgrass seed or plant without damage to the basic grasses. Our 1960 pre-emergent test is another step toward this goal.

Materials and Methods

This study was carried out on an old stand of lawn-type turf consisting primarily of colonial bentgrass with a uniform yet lesser amount of Kentucky bluegrass and creeping red fescue. A heavy stand of crabgrass was present during the previous season and the test area was also overseeded with crabgrass seed in early April of 1960.

The soil was classified as a Bridgehampton silt loam, a deep, well-drained soil. Fertility was low and the pH reading was 5.7. To favor crabgrass growth, the cutting height was maintained at 1 inch and fertilizer was applied once, after crabgrass germination. There was a 5 to 10 day interval between mowings, governed by the growth.

The 1960 growing season was drier and cooler than average. There was no water supply so the turf received only natural precipitation.

The trial was established using a randomized block design with each treatment in triplicate. Thirty-seven treatments were included on plots measuring 4 x 10 feet each.

The materials were applied between April 16 and April 26. Grass growth was slow because of the cool spring. Wettable powders and emulsifiable concentrates were applied in water at 250 gallons per acre, with a low pressure sprayer employing a flat-fan type nozzle. The dry formulations were applied by hand in a mixture with sand except the Halts formulations which were applied with a Scott's spreader at a setting of ten.

Periodic observations were made following the treatments to observe turf injury or discoloration. Final control readings were taken on September 23, 1960, by counting the number of crabgrass plants in two, one-square-foot quadrats in each plot.

The herbicidal materials used, the percent active ingredient in each compound, and the rates of application were as follows:

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[1] Contribution No. 1016. Rhode Island Agricultural Experiment Station.
[2] Graduate Assistant in Agronomy and Associate Agronomist respectively.

1.	L-13489	Diphenyllactelonitrile (12.5%) at 40, 30, and 20 pounds of active per acre.
2.	L-31864	N, N-di (n - propyl) -2,6-dinitroaniline) (12.5%) at 20, 10 and 5 pounds of active per acre.
3.	L-34314	N, N-dimethyl -α- α-diphenylacetamide (5.0%) at 20, 10, and 5 pounds of active per acre.
4.	Dacthal	Dimethyl ester of tetra chloroterephthalic acid (50.0% W.P.) at 15, 10 and 5 pounds of active per acre.
5.	Dac-893	Dimethyl ester of tetra chloroterephthalic acid (1.5% granular) at 15, 10 and 5 pounds of active per acre.
6.	Zytron M-1329	O-(2,4-dichlorophenyl) O-methyl isopropylphosphoramidothioate (2 pounds of Zytron per gallon) at 20 and 10 pounds active per acre.
7.	Zytron M-1662	O-(2,4-dichlorophenyl) O-methyl isopropylphosphoramidothioate (8.0%) at 20 and 10 pounds of active per acre.
8.	Niagara 5996	2,6-dichlorobenzonitrile (40% W.P.) at 2 and 4 pounds active per acre.
9.	Chlordane CS-201	(10.0% active on vermiculite) at 30, 15, and 7.5 lbs. active per acre.
10.	Chlordane	(20.0%) at 60 pounds active per acre.
11.	Chlordane + DSMA	(10.0% chlordane and 1.0% DSMA) at 60 pounds chlordane plus 6.0 pounds DSMA per acre.
12.	Chip-Cal	Tricalcium arsenate (73.0%) at 508 pounds active per acre.
13.	(GC) Granular Calcium Arsenate	Tricalcium arsenate (73.0%) at 508 pounds active per acre.
14.	Di-Met P-C-CT	Tricalcium arsenate (79% active plus 3.5% nitrogen) at 344 pounds active per acre.
15.	No crab	Calcium arsenate (47.2%) at 370 pounds active per acre.
16.	Halts F-25	17% modified formulations of F-2b.
17.	Halts F-24	17% modified formulations of F-2b.
18.	Halts F-26	17% modified formulations of F-2b.
19.	Halts F-2b	23% Chlordane

At Scott's Spreader Setting 10.

20. Halts F-29 8% Zytron)
21. Halts F-20a 4% Dacthal) At Scott's Spreader
22. Check) Setting 10.

Results and Discussion

Table I shows the results obtained with the various chemicals used in this experiment. All rates of application referred to below are on the acre basis.

L-13489 at the 40 pound rate gave 99 percent control. The 30 and 20 pound rates gave about 90 percent control.

L-31864 gave 99, 96 and 90 percent control for 20, 10 and 5 pound rates respectively. No discoloration was noted.

L-34314 at the 20 and 10 pound rates produced very good control but the basic turfgrass was reduced by 97 and 95 percent. Discoloration was severe right after application. At the 5 pound rate discoloration was moderate, permanent injury was 50 percent and control only 64 percent.

Dacthal at 15, 10 and 5 pounds gave excellent control. No discoloration was noted for any of the rates but a slight decrease in turf was noted at the 15 pound rate.

Zytron M-1329 gave excellent control at the 20 and 10 pound rates. Some discoloration was noted at the heavier rate.

Zytron M-1662 resulted in 100 percent control at the 20 pound rate and 88 percent at the 10 pound rate.

Niagara 5996 was not effective at either the 2 or 4 pound rate.

The two tricalcium arsenates, Chip Cal and (GC) T.C.A. at the 508 pound rate produced 100 percent control. Chip Cal discolored the basic grass very slightly.

100 percent control was obtained with no crab at a 370 pound rate. Mouse-eared chickweed was strikingly bleached and killed with this chemical.

Di-met P-C-CT at 344 pounds produced 96 percent control.

Chlordane at 60 pounds gave 75 percent control.

Chlordane + DSMA resulted in 82 percent control.

Chlordane CS-201 at 30 pounds gave 37 percent control whereas 15 and 7.5 pounds resulted in no control. There was no discoloration or injury with any of the chlordane materials.

Halts F-24, Halts F-26, Halts F-29, and Halts F-20a produced more than 95 percent control. The two remaining Halts formulations, F-25 and F-2b gave 88 and 82 percent control respectively. Only F-24 produced any discoloration and it was slight.

The crabgrass plants in our plots were not as aggressive as would be expected in a lawn area that received supplementary water. August was a dry month which aggravated this condition. The results are not compromised, however, because the individual crabgrass plants were picked out of the square foot quadrats and control was based on comparison with the check plots.

Summary and Conclusion

L-13489, L-31864, Lacthal, Zytron, tricalcium arsenate, calcium arsenate, Halts (F-24, F-26, F-29, F-20a) gave a highly significant degree of control without discoloration or injury to the basic turf.

Halts F-25, Halts F-2b, Chlordane and Chlordane + LSMA resulted in 88% to 75% control which is highly significant but hardly satisfactory on the basis of crabgrass plants per square foot.

Niagara 5996 and Chlordane CS-201 did not give significant control at the rates used.

L-34314 showed no selectivity; injuring the basic grasses as severely as the crabgrass.

Acknowledgment

Appreciation is extended to Eli Lilly and Co. for support in conducting this research program.

Table 1. Herbicides and rates of usage, initial and permanent turf injury and crabgrass control obtained in the 1960 pre-emergence trials.

Material	Rate of Active Per Acre	Initial Discolor-ation*	% Turf Reduction	Plants Per Sq. Ft.	Percent Over Check
L-13489	40	0	14	.3	99
L-13489	30	0	7	3.5	89
L-13489	20	0	5	2.5	93
L-31864	20	0	11	.2	99
L-31864	10	0	7	1.3	96
L-31864	5	0	4	3.2	90
L-34314	20	4	97	0.0	100
L-34314	10	4	95	1.5	96
L-34314	5	2	50	13.3	64
Dacthal	15	0	12	.2	99
Dacthal	10	0	13	0.0	100
Dacthal	5	0	9	.3	99
Dac-893	15	0	25	0.0	100
Dac-893	10	0	15	0.0	100
Dac-893	5	0	5	1.8	95
Zytron M-1329	20	1	4	0.0	100
Zytron M-1329	10	0	5	.8	98
Zytron M-1662	20	0	11	0.0	100
Zytron M-1662	10	0	4	4.5	88
Chlordane CS-201	30	0	7	23.2	37
Chlordane CS-201	15	0	6	42.3	0
Chlordane CS-201	7.5	0	2	38.0	0
Chlordane	60	0	2	9.3	75
Chlordane + DSMA	60. + 6	0	5	6.8	82
Niagara 5996	2	0	7	31.5	15
Niagara 5996	4	0	4	55.5	0
Chip-Cal	508	+	11	0.0	100
(GC) T.C.A.	508	0	7	0.0	100
No Crab	370	+	12	0.0	100
Di-met P-C-CT	344	0	13	1.3	96
Halts F-25	-	0	5	4.3	88
Halts F-24	-	1	5	.8	98
Halts F-2b	-	0	3	6.5	82
Halts F-26	-	0	2	1.3	96
Halts F-29	-	0	13	.7	98
Halts F-20a	-	0	16	0.0	100
Check	-	0	6	37.0	-
			LSD at 5% =	17.4	
			LSD at 1% =	23.1	

* Discoloration Index 0 = none, + = <1, 5 = permanent injury.

POST-EMERGENCE CONTROL OF CRABGRASS IN LAWN TURF WITH CHEMICALS[1]

J. A. Burke and C. R. Skogley[2]

This paper compares the effectiveness of several materials, some available commercially and some in the experimental stage, for the control of crabgrass which has already emerged from the soil.

MATERIALS AND METHODS

The 1960 post-emergence crabgrass control experiment was conducted on lawn-type turf which contained a mixture of bluegrass, fescue, and colonial bentgrass with the bentgrass predominating. To insure an adequate crabgrass infestation, seed of smooth crabgrass (Digitaria ischaemum) was broadcast over the area and the grass was mowed and fertilized to favor the growth and spread of the crabgrass. The area received no water other than from natural precipitation.

The plots were forty square feet (4 feet by 10 feet) in size. Twenty-two treatments were included in the test and a randomized block design was employed with 3 replications.

The materials used, the percent active ingredients, and the rates applied were as follows:

1. Shell SD 6623 at 2, 4, and 6 pounds of actual material per acre, both with and without a non-ionic wetting agent, and at 8 pounds of actual material per acre without a wetting agent.

2. Dimet + 2 (8% dodecyl ammonium methyl arsonate and 8% octyl ammonium methyl arsonate plus 3.43% 2, 4-Dichlorophenoxy acetic acid) at 3.4 pounds of actual AMA and 0.73 pounds of actual 2, 4-D per acre.

3. Artox (8% octyl and 8% dodecyl ammonium methyl arsonate) at 4 pounds of actual AMA per acre.

4. Weedone (12.3% disodium methyl arsonate) at 4 and 6 pounds of actual DMA per acre.

5. Clout (2.5% disodium methyl arsonate hexahydrate) at Scotts spreader settings 7 and 10 (2.83 and 5.66 pounds of actual DMA per acre, respectively).

6. Sodium arsenite (4 pounds of arsenic trioxide per gallon) at 0.75 pound of actual material per acre.

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[1]Contribution No. 1014. Rhode Island Agricultural Experiment Station.
[2]Graduate Assistant in Agronomy and Associate Agronomist respectively.

7. Cacodylic acid (100%) at 0.5 pound per acre.

8. PM 2,4-D (6.77% phenylmercuric acetate and 4.44% 2,4-Dichlorophenoxy acetic acid) at 0.8 pound of actual material per acre.

9. F W 734 (25% emulsifiable concentrate of 3,4 dichloropropionanilide) at 0.5 pound and 1 pound of actual per acre.

10. Void (3.15% disodium methyl arsonate hexahydrate) at Scotts spreader setting 8 (4.12 pounds of actual DMA per acre).

The 2 pound rate of the SD 6623 was tested with single and double applications; the 4, 6, and 8 pound rates of this material were applied only once. All other materials were applied 3 times.

The first application of all materials was made on June 29, 1960. The maximum air temperature on that date was 87°F. at the 3-inch level. The plots receiving a second application were treated on July 7, with a maximum temperature of 86°F. at the 3-inch level. The third application was made on July 19, with a maximum 3-inch temperature of 85°F. All three treatments were made on clear, bright days, during periods of dry weather. The total precipitation from June through September was 14.9 inches (about normal) but August was a dry month, and September a wet one.

The dry formulations, Clout and Void, were applied with a Scotts spreader set at the manufacturer's suggestion. All other materials were applied in water with a low-pressure hand-pump sprayer at a rate of 270 gallons of water per acre.

Discoloration readings were taken on July 5, July 11, and July 22. Permanent injury ratings and an estimate of control were taken on August 31. The final percent control given by each treatment was based on counts of the number of crabgrass plants growing in a 2 square foot area as compared to the number growing in the same area in the check plots. These counts were made on September 29, 1960, for each of the 66 plots.

RESULTS AND DISCUSSION

Table I shows the results obtained with the chemicals used in this experiment.

SD 6623 discolored the turf rather severely at the higher rates, and did not give adequate control at any of the rates used, despite some improvement with the addition of a wetting agent.

Limet + 2 at 3.4 pounds of AMA and 0.73 pound of 2, 4-D gave 95% control and caused only very slight discoloration after each of the 3 applications.

Artox at 4 pounds of AMA per acre gave 100% control in this test. Discoloration increased somewhat after each application, but remained slight.

Weedone at 4 pounds of DMA per acre gave 98% control of crabgrass, with slight discoloration after the first application, and slight to moderate discoloration after the two later applications. At the 6 pound rate, 99% control was achieved, and quite severe discoloration occurred after the third application.

Clout gave 87% and 99% control at 2.83 and 5.66 pounds of DMA per acre, respectively. Only slight discoloration resulted from either rate.

Sodium arsenite at 0.75 pound of As_2O_3 per acre did not control crabgrass in this test, and caused slight discoloration of the turf.

Cacodylic acid at 0.5 pound per acre gave no control, and resulted in moderate to severe discoloration.

PM 2, 4-D applied at 0.8 pound per acre failed to adequately control crabgrass. Moderate discoloration was observed after the last two applications.

FW 734 at 0.5 pound and 1 pound did not control crabgrass significantly and the highest rate caused slight discoloration.

Void at 4.12 pounds of DMA per acre produced inadequate control in this test.

At the end of the experiment, no permanent injury was noted from any of the treatments. It was observed that each plot which showed adequate control also contained little or no clover. The plots receiving the 1-pound rate of FW 734 also contained little or no clover.

After the second application, severe chlorosis of dandelion plants was observed in the plots receiving SD 6623 at 2 pounds per acre with repeated treatments and also in those receiving the single applications of 4 and 6 pounds with a wetting agent added.

Injury to chickweed occurred in plots treated with SD 6623 at 2 pounds per acre applied twice, and with all the higher application rates of this material. Similar inhibition of chickweed was observed after the second application in plots receiving the following materials: Dimet + 2, Artox, Weedone (at both 4 and 6 pounds), sodium arsenite, PM 2, 4-D, and FW 734 at 1 pound per acre.

SUMMARY AND CONCLUSIONS

Post-emergence crabgrass control tests were conducted at the University of Rhode Island during the summer of 1960. Materials used which gave a highly significant measure of control were:

1. Dimet + 2 at 3.4 pounds of AMA and 0.73 pound of 2, 4-D per acre - 95% control.

2. Artox at 4 pounds of AMA per acre - 100% control.

3. Weedone at 4 and 6 pounds of DMA per acre - 98 and 99% control, respectively.

4. Clout (DMA) at Scotts spreader settings 7 and 10 - 87 and 99% control, respectively.

A significant, but not satisfactory, degree of control was obtained with PM 2, 4-D. In this test SD 6623, sodium arsenite, cacodylic acid, FW 734, and Void failed to control crabgrass.

None of the materials caused discoloration severe enough to result in permanent injury to the basic grasses.

Table I. Post-Emergence Control of Crabgrass in Lawn Turf with Chemicals.

Material	Active Ingredient	Pounds Per Acre	No. of Applications	Discoloration[1] July 5	July 7	July 22	Control No. of Plants Per 2 Sq. Ft.	Percent Control[2]
SD 6623	3 lb./gal.	2.0	1	0.3	1.7	0.0	41.7	0
SD 6623	3 lb./gal.	2.0	2	0.2	0.7	0.1	48.7	0
SD 6623 + W.A.	3 lb./gal.	2.0	1	0.1	0.5	0.0	37.7	3
SD 6623 + W.A.	3 lb./gal.	2.0	2	0.1	0.8	0.4	34.0	12
SD 6623	3 lb./gal.	4.0	1	0.1	2.3	0.1	15.7	59
SD 6623 + W.A.	3 lb./gal.	4.0	1	0.4	2.8	0.2	30.0	22
SD 6623	3 lb./gal.	6.0	1	1.1	2.7	0.3	50.3	0
SD 6623 + W.A.	3 lb./gal.	6.0	1	0.7	3.5	1.0	32.0	17
SD 6623	3 lb./gal.	8.0	1	1.7	3.7	1.1	56.7	0
Dimet + 2	16.0 AMA + 3.43 2, 4-D	3.4 AMA + 0.7 2, 4-D	3	0.4	0.7	0.7	2.0	95
Artox	16.0 AMA	4.0	3	0.2	0.7	1.0	0.0	100
Weedone	12.3 DMA	4.0	3	0.4	1.3	1.7	0.7	98
Weedone	12.3 DMA	6.0	3	1.1	2.2	2.8	0.3	99
Clout	2.5 DMA	2.8	3	0.0	0.0	1.0	5.0	87
Clout	2.5 DMA	5.6	3	0.0	0.0	0.2	0.3	99
Na Arsenite	4 lb./gal.	0.7	3	1.0	1.7	1.1	42.0	0
Cacodylic Acid	100.0	0.5	3	1.1	3.7	2.0	61.0	0
PM 2,4-D	10.0	0.8	3	0.4	1.9	2.0	12.0	69
FW 734	25% E.C.	0.5	3	0.0	0.1	0.3	28.0	28
FW 734	25% E.C.	1.0	3	0.2	0.7	1.0	33.3	14
Void	3.15 DMA	4.1	3	0.0	0.1	0.0	31.7	18
Check	—	—	—	0.0	0.0	0.0	38.7	—

LSD @ 5% = 24.5
LSD @ 1% = 32.8

[1]Discoloration Index: 0 = No discoloration, 5 = Complete discoloration.
[2]Percent control based on comparison with check.

A TEST OF CHEMICALS FOR CRABGRASS CONTROL IN TURF[1]

John R. Havis[2]

The area chosen for this test had been seeded to a fairway mixture about fifteen years previously. It had received little or no fertilizer, and was mowed with a sickle bar three or four times a year. The grasses were a mixture of bluegrass and fescues. Miscellaneous weeds were present but very little natural crabgrass.

During the last two weeks of April, 1960, the grass in the area to be used was mowed to 1 1/2 inches in height, fertilized with 15 pounds of 10-6-4, and a light top dressing of soil was applied. The area was then seeded with 4 pounds of weed seeds having a high percentage of crabgrass. The area, 20 by 80 feet, was divided into 32 plots 5 by 10 feet in size. This provided plots for 8 treatments, including a check plot, replicated four times.

Five pre-emergence herbicides were applied May 5 at rates according to label directions as follows:

Granular 23% chlordane at 6 lb. per 1,000 square feet
Pelleted 73% tricalcium arsenate at 12 lb. per 1,000 square feet
Pax-combination of arsenicals + amm. sulfate at 20 lb. per 1,000 sq.ft.
Granular 2.3% dacthal at 10 lb. per 1,000 square feet
Granular 8% zytron at 6 lb. per 1,000 square feet

These applications were made less than three weeks before the first crabgrass seedlings could be identified on May 23.

Two treatments of post-emergence herbicides were included in the experiments:

Granular 3% DSMA at 3 lb. per 1,000 square feet was applied five times - June 21, July 5, July 8, July 12, and July 28.

Liquid 16% AMA at 15 oz. per 1,000 square feet was applied two times - June 20 and July 28.

Irrigation was not available for this experiment. Approximately two inches of rain fell in the week of May 8 to 15, which was between the time of the pre-emergence applications and emergence of crabgrass. The rainfall pattern for the remainder of the season was favorable for satisfactory growth of turf, except for the period June 15 to 30 when the soil became quite dry. A second application of fertilizer was made at the end of June. The test area was mowed weekly.

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Results

The procedure of seeding crabgrass over a light topdressing resulted in a uniform population of crabgrass and a high degree of agreement among replications.

The treatments were rated on July 25 by one person, as follows:

TREATMENT NO.	CHEMICAL	RATING	REMARKS
1	Chlordane	Poor	
2	Ca Arsenate	Poor	
3	Pax	Poor	Least control of all chemicals
4	Dacthal	Excellent	
5	Zytron	Excellent	Slightly better than No. 4
6	Check	None	
7	DSMA (Gran.)	Poor	
8	AMA (Liq.)	Fair	Definite injury to fescues

Three people made independent ratings in mid-September:

TREATMENT		EST. PERCENT CONTROL			RATINGS		
NUMBER	CHEMICAL	A	B	C	A	B	C
1	Chlordane	31	46	38	Poor+	Poor	Poor
2	Ca Arsenate	32	60	45	Poor	Poor+	Poor
3	Pax	32	42	31	Poor	Poor	Very Poor+
4	Dacthal	94	94	97	Excellent	Good+	Good+
5	Zytron	95	96	99	Excellent	Excellent	Excellent
6	Check	0	0	0	None	None	None
7	DSMA (Gran.)	26	46	34	Poor	Poor	Poor
8	AMA (Liq.)	44	48	51	Poor+	Poor+	Poor

The following observations were noted at the time of the September rating:

Chlordane, Ca Arsenate, Pax - No indication of injury.
Zytron - No indication of injury; grass had excellent appearance.
Dacthal - General appearance not quite as good as Zytron.
DSMA and AMA - Both post-emergence treatments injured fescues, although considerable recovery had taken place by the middle of September.

Conclusions

Under the conditions of this experiment, zytron and dacthal gave satisfactory control of crabgrass in a bluegrass-fescue turf. Chlordane and the two arsenic products did not give satisfactory control.

Both granular and liquid forms of the methyl arsonates, used post-emergence, injured fescues noticeably. Neither form gave satisfactory control. Low soil moisture at certain times of application probably contributed to the turf injury.

This experiment was supported by the Massachusetts Turf and Lawn Grass Association.

THE RESPONSES OF TURF AND CERTAIN TURF WEEDS TO DACTHAL [1/]

L. E. Limpel, Paul H. Schuldt, and Frank Batkay [2/]

Abstract

The ability of DACTHAL (dimethyl ester of tetrachloroterephthalic acid) to control crabgrass in turf by a single application of 3 to 18 pounds per acre in spring before crabgrass germination, was evaluated in ten field trials over the three-year period, 1958-1960. The tests were conducted in Westchester County, N. Y. All experiments were randomized block designs of three to six replicates with plots ranging in size from 25 to 100 square feet. DACTHAL wettable powder (W-50) was sprayed in 100 or 200 gallons of water per acre with a one-gallon hand pumped sprayer equipped with a Teejet nozzle. Granules and other dry formulations were applied either with a fertilizer spreader, or broadcast by hand from a jar equipped with a perforated cap.

During these three years, DACTHAL has consistently given excellent crabgrass control. This excellent performance occurred in spite of extreme climatological variations, i.e. 1958 was a very wet year, 1959 was relatively normal, while 1960 had extremes of dryness and wetness within the season. Formulated as the W-50, as six different experimental granules, or as RID [3/], it provided 83-99 per cent seasonal control at dosages of 9 to 12 pounds per acre. It was more effective and reliable than either of the two commercial crabgrass pre-emergence control agents, chlordane at 60 pounds per acre and calcium arsenate at 444 pounds per acre. The experimental granules were 1.25 or 1.5 per cent active and disintegrated in water at fast, slow, or intermediate rates. Against crabgrass in turf, formulation differences had little if any effect on performance of DACTHAL, but in one test, there was a suggestion that granular formulations possessed a longer residual activity than the wettable powder.

In two out of three seasons, application of DACTHAL after crabgrass germination, when the seedlings possessed 1 to 2 leaves, resulted in greatly reduced crabgrass control. Over the three-year period, several other turf weeds have been found to be susceptible to pre-emergence applications of DACTHAL: common chickweed (<u>Stellaria media</u>), spotted spurge (<u>Euphorbia maculata</u>), and goosegrass (<u>Eleusine indica</u>).

Data indicate that DACTHAL can be safely and conveniently fitted into a normal turf care program. This pre-emergence herbicide has been found to be

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1/ DACTHAL is the trade-mark of the Diamond Alkali Company product, dimethyl ester of tetrachloroterephthalic acid.

2/ Boyce Thompson Institute for Plant Research, Inc., Yonkers, N. Y. Diamond Alkali Company Fellowship.

3/ RID was supplied by Swift & Co.

compatible with grub-proofing insecticides, with 2,4-D, and with ureaform lawn fertilizers. Its residual activity, based on five replicated tests over a three-year period, is such that areas treated with dosages up to 18 pounds per acre at the recommended time in spring can be safely reseeded in fall to fescues and bluegrasses, alone or in mixtures. This fits in with normal renovation procedures. However, such reseeding is often found unnecessary because superior turf growth follows the elimination of crabgrass competition.

In extensive evaluations of tolerance of pure stands of turf grass in 1960, it has been found that established stands of Kentucky and Merion bluegrasses one year old or even younger as well as perennial ryegrass are completely tolerant of DACTHAL at the recommended and higher dosages. Astoria bentgrass, one year old, has been found tolerant of DACTHAL at the recommended rate of 10 pounds per acre. Chewing's fescue one year old at the time of treatment with DACTHAL at 10 pounds per acre was slightly thinned at the height of its summer dormancy, but had completely recovered by early fall.

The following toxicological data reveal that this herbicide is not a hazardous material to use. The acute oral LD50 on rats is greater than 3 g./kg. of body weight, and the acute dermal LD50 on rats is greater than 10 g./kg. of body weight. When included in the diet at a level of 1 per cent for 30 days, it had no deleterious effects on rats. DACTHAL is non-toxic to bluegills or goldfish. It is not irritating to the skin or eyes, and does not possess a disagreeable odor. However, complete toxicological data are not yet available and the material should be handled with the usual precautions.

This herbicide is a valuable addition to the array of pesticides currently available for use on turf. Its safety, compatibility, and residual properties are such that it can easily be fitted into the commonly recommended turf maintenance programs.

CONTROL OF SEEDLING GRASSES IN TURF WITH DIPHENYLACETONITRILE AND A SUBSTITUTED DINITROANILINE

E. F. Alder, W. L. Wright, and Q. F. Soper[1]

Introduction

Over the course of two seasons a total of 32 turf field tests containing over 1500 plots were conducted in order to evaluate two herbicidal materials for their selective action against seedling grasses in turf. The first of these materials is diphenylacetonitrile which was coded as L-13489 and now has the tentative generic name diphenatrile. The second is N,N-di(n-propyl)-2,6-dinitroaniline which was coded as L-31864. No generic name has as yet been coined for this material, and it will continue to be referred to here as L-31864.

Procedure

Field tests were placed in areas known to be heavily infested with seedling weed grasses the preceding year. In one test location the turf was disturbed the preceding fall in order to leave open areas for weed grass infestation the following spring. Smooth crabgrass (*Digitaria ischaemum*) was the dominant weed grass in most plots. Hairy crabgrass (*D. sanguinalis*), yellow and green foxtail (*Setaria lutescens* and *S. viridis*) and goosegrass (*Eleusine indica*) were present in several of the plots. In each test all treatments were replicated four times in a randomized block design. Turf plots were four by six feet. Two-foot buffers were left between plots and four-foot buffers between replications. The seedling grasses in four foot-square quadrats in each plot of the four replications were counted and averaged. In test areas of low weed infestation, entire plot counts were made. The final count was taken 60-100 days after treatment in the first of the test seasons, and 120-140 days after treatment in the second test season.

1/ Eli Lilly and Co., Agricultural Research Center
Greenfield, Indiana

Diphenatrile Results

During the first test season diphenatrile was tested at rates of 8, 16, and 32 lb/A. A summary of these results is presented in Table 1.

Table 1. Summary of Diphenatrile Results
Applied 4-21 to 5-26, Counted 7-24 to 8-24

Rate (Lb/A)	Percent Seedling Grass Control
0	--
8	28
16	77
32	95

Applications made in the fall showed very little activity the following season, even at rates as high as 48 lb/A. Hence, fall treatment with the material is not recommended.

In the spring of the second test season diphenatrile was applied at 20, 30, 40, and 50 lb/A on turf of widely different quality and with light to extremely heavy seedling grass infestations. A summary of results obtained from these treatments is presented in Table 2.

Table 2. Summary of Diphenatrile Results
Applied 4-12 to 5-18, Counted 8-24 to 8-31

Rate (Lb/A)	Percent Seedling Grass Control
0	--
20	95
30	98
40	98+
50	99+

Control of seedling weed grasses at the recommended rate of 30 lb/A was effected for a period of 120 to 140 days. It was possible, however, to seed turf grasses successfully 86 days after treatment. There was no damage to any of the established turfs tested -- even at greatly elevated rates.

Diphenatrile is an extremely safe material. It has an acute oral LD_{50} in mice of greater than 3500 mg/kg. It has not caused dermal irritation and possesses no unpleasant odor. The remarkable selectivity against seedling grasses and safety to ornamental plants (Table 3) makes it possible to use the material as a seedling grass herbicide in flower beds, as well as in shrubbery plantings and broadleaf ground cover.

Table 3. Response of Weed Grasses, Turf Grasses, and Ornamentals to Diphenatrile

Susceptible Grasses	Resistant Turf Grasses	Resistant Ornamentals
Crabgrass, small	Bluegrasses	Annual flowers
Crabgrass, large	Bermuda	Evergreen shrubs
Foxtail, yellow	Bentgrasses	Broadleaf shrubs
Foxtail, green	Centipede	Myrtle & Ivy
Goosegrass	Fescues	Roses
Sandbur	St. Augustine	Chrysanthemum
Turfgrass seedlings	Zoysia	Ornamental bulbs

Dinitroaniline Results

Study of the general herbicidal activity of a series of unsubstituted dinitroanilines revealed that the 2,6 dinitro compound was markedly more active than the 2,4 dinitro, which was, in turn, more active than the 2,3 dinitroaniline. When dialkyl substitutions are made on the amino group of the 2,6 dinitro molecule, the resultant compounds lose general herbicidal properties, but become highly selective against seedling grasses in pre-emergence applications. The di-n-propyl has proved to be the most active dialkyl substitution. Activity can be further increased by appropriate substitutions in the 4-position of the ring. The herbicidal order of activity of the 4-position substituents has been determined as $CF_3 > CH_3 > Cl > H$. The 4-CF_3 (L-36352) has been given the tentative generic name trifluralin. The 4-CH_3 (L-35455) bears the tentative name of dipropalin. The 4-Cl is still coded as L-34906 and the unsubstituted hydrogen compound is the parent L-31864.

Extensive field testing of L-31864 was conducted under a wide variety of turf conditions, and the material was found to be highly active against seedling grasses. Table 4 presents a summary of the test data.

Table 4. Summary of L-31864 Results
Applied 4-12 to 5-18, Counted 8-24 to 8-31

Rate (Lb/A)	Percent Seedling Grass Control
0	--
2.5	86
5	93
10	96
20	98
30	99+
40	99+

There was no evidence of damage on any of the turfs tested. For 120-140 day control of seedling grasses it would appear that 7-8 lb/A of L-31864 is sufficient. Granular formulations were found to provide slightly longer control than emulsifiable sprays. L-31864 is somewhat less selective than diphenatrile in that it does show some pre-emergence activity on certain broadleaf species.

Greenhouse and limited field tests have shown that trifluralin and dipropalin possess the same selectivity as L-31864. Their greater activity makes it appear that these two compounds are the most active seedling grass herbicides yet discovered, with perhaps 4 to 5 lb/A sufficient for full-season control. An intensive evaluation program on these two materials is now under way.

Summary:

1. Diphenylacetonitrile, now given the generic name diphenatrile, has controlled seedling grasses for 120-140 days at application rates of 30 lb/A. Its unique selectivity against seedling grasses makes possible its use in flower beds and shrubbery plantings, as well as on turf.

2. A highly active series of substituted dinitroanilines possessing selective herbicidal activity against seedling grasses has been discovered. The N,N-di-(n-propyl)-2,6-dinitroaniline, coded as L-31864, has given excellent control of seedling grasses at 10 lb/A. The 4-CF_3 derivative (coded as L-36352 and tentatively named trifluralin) and the 4-CH_3 (coded as L-35455 and tentatively named dipropalin) have shown even greater activity than the parent L-31864.

PRE-EMERGENCE CRABGRASS CONTROL TRIALS — 1960

J. E. Gallagher[1] and R. J. Otten[1]

Objectives

Tests in the Amchem greenhouses during the winter of 1959-1960 indicated that several new organic arsenical materials had the properties of selective pre-emergence crabgrass control.... that is, preventing crabgrass seeds from growing past the seedling stage while allowing turfgrass seeds to sprout and grow normally.

Outdoor tests performed during the spring and summer of 1960 were designed to test these and other chemicals under field conditions for the following properties:

a) effective pre-emergence crabgrass control for an entire season with one spring application of the chemical.

b) tolerance of turfgrass seeds planted immediately or at intervals after application of the chemical.

c) tolerance of turfgrass seedlings to applications of the chemical at different stages of growth.

Location

The pre-emergence crabgrass test was performed in the practice fairway of Oak Terrace Country Club, Ambler, Pa. The natural turf present is a mixture of primarily bluegrass and fescue with some native bent. The area is on a low maintenance program and develons a severe crabgrass infestation every year.

The seeding trials were performed on the Amchem Research Farm, Ambler, Pa. in areas prepared especially for these tests.

Method

a) Pre-emergence crabgrass trials

Plots 6' x 10' (60 sq. ft.) were laid out in a random design. Each treatment was replicated three times. Dry materials were weighed out in advance and spread by hand. Liquid materials or wettable powders were measured out, mixed with water (equivalent to 180 gpa) and applied with a small-plot sprayer. Natural rainfall was the only source of water in this area.

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b) Seed tolerance trials

Plots 6' x 20' (120 sq. ft.) were laid out in a newly fitted area. Dry and liquid materials were applied as in the pre-emergence trials. One foot wide rows of different grasses were seeded the following day and at intervals of one, two and four weeks. Half of each plot was raked lightly before and after seeding. No mulch was used, but irrigation was available and was used as needed to keep the soil surface damp.

c) Seedling tolerance trials

Strips 5' x 100' (500 sq. ft.) were seeded to pure stands of Seaside bentgrass, Kentucky bluegrass, Chewings fescue, perennial ryegrass and smooth crabgrasses and White Dutch clover. At two time intervals after sprouting, 18-inch bands of chemical were applied across these strips with a 6-inch check strip left between each treated band. Dry formulations were weighed out in advance and applied by hand. Sprayed materials were mixed in the equivalent of 180 gpa of water and applied with a single nozzle backpack sprayer. No mulch was used, but irrigation was available and was used as needed to keep the soil surface damp.

Observations

a) Pre-emergence crabgrass trials

On June 15, August 15 and September 30, visual estimates were made of the proportion of each plot infested with crabgrass. The nine check plots were averaged and taken as the standard. The three replications of each treatment were averaged and compared to the standard to determine the percent crabgrass control produced by each treatment. These results are reported in Table I.

b) Seed tolerance trials

On July 8 and August 25, visual estimates were made of the stand of grasses in each plot. The stand of grasses in the check plots was rated as "10" and stands in treated plots were related to this. A rating of "0" indicates complete inhibition of seed growth. Results are reported in Table II.

c) Seedling tolerance trials

On June 6 and July 8, visual estimates were made of the injury and/or reduced stand of each species of seedling grass. The stand of grasses in the check rows was rated as "10" and stands in treated rows were related to this. A rating of "0" indicates complete post-emergence kill of seedling grasses. A rating of "7" or less indicates objectionable injury. Results are reported in Table III.

Discussion

a) Pre-emergence crabgrass control trials

The products and experimental materials reported in Table I are from a total of 27 field tested in 1960 (210 plots). The materials not reported were all experimental and did not provide satisfactory pre-emergence crabgrass control.

Products: Of the materials tested, it is interesting to note the difference between the performance of the two tricalcium arsenate products. Variation in crabgrass control with chemicals from different sources has been reported elsewhere, and in this case can not be attributed to the 2,4-D/2,4,5-TP content alone. The two chlordane products (on vermiculite) were not effective at any time during the season. The dacthol product produced excellent pre-emergence crabgrass control that lasted throughout the season.

Experimental materials: All rates of DAC-893, Zytron 1328 and Zytron 1481 used in this test produced satisfactory to excellent pre-emergence crabgrass control. The liquid Zytron 1328 appeared to be slightly superior to the vermiculite Zytron 1481. Of the AMCHEM experimental formulations, XF-834 provided satisfactory control throughout the season. The three XF compounds reported here had been taken to the field after screening eight similar compounds in the greenhouse.

b) Seed tolerance trials

XF-832, 834, 833: These chemicals produced no significant reduction in the stand of bent, blue, fescue or rye grasses at 3/4 or 1½ lb/1000 sq.ft. The poorer stands of grasses seeded four weeks after treatment can be explained by the severe stand of foxtail that developed in the area before the fourth week and competed with the germinating grasses. (See the check plots.)

Zytron 1328 and 1481: Except for a little rye grass, these materials inhibited the germination of grasses for the entire four-week period. This is similar to its long-term inhibition of crabgrass germination.

Chlordane (product): This material produced no significant reduction in the stand of bent, blue, fescue or rye at any date of seeding.

Dacthol (product): This material allowed nothing except a little ryegrass to sprout when seeded up to 4 weeks after treatment.

Tricalcium arsenate + 2,4-D/2,4,5-TP (product): This material greatly reduced the germination of all grasses planted up to four weeks after treatment. Unexpectedly, bentgrass grew better than any of the other grasses.

c) Seedling tolerance trials

XF-832: Seedling bent, blue and rye grasses were not injured when treated with 3/4 or $1\frac{1}{2}$ lb/1000 sq.ft., 3 or 6 weeks after seeding. Fescue and clover were injured somewhat at both rates. While this chemical is intended as a pre-emergence crabgrass material, it caused a significant reduction in the stand of crabgrass when applied post-emergence to seedling crabgrass in the 2-leaf (1 inch) stage. Control was almost complete at the $1\frac{1}{2}$ lb/1000 sq. ft. rate.

XF-834: Seedling fescue and clover were slightly affected but bent, blue and rye grass were not injured by either rate. This chemical had greater post-emergence activity than AMA-41 on seedling crabgrass, controlling crabgrass completely at both rates and times of application.

XF-833: This was the most selective chemical of the three having practically no effect on turf grasses and clover. It was slightly less effective post-emergence on seedling crabgrass.

Zytron 1328 and 1481: The dry form (1481) produced slight injury on bent, blue and fescue, while the liquid form (1328) produced considerable injury.

Chlordane (product): This material produced no significant injury on seedling turf grasses or clover.

Dacthol (product): This material produced only very slight injury, most of it in the early treatment.

Tricalcium arsenate + 2,4-D/2,4,5-TP (product): This material produced significant discoloration and stand reduction of all turf grasses as well as crabgrass.

Conclusions

Based on 1960 field tests, it is apparent that XF-832, within the range of rates tested, most nearly achieves the objectives stated at the beginning of this paper.

Zytron and Dacthol, while offering excellent pre-emergence crabgrass control and satisfactory turf tolerance, have the disadvantage of preventing growth of turfgrass seeds planted within four weeks after application of these chemicals.

TABLE I -- Comparison of Products and Experimental Materials for Pre-emergence Crabgrass Control

Location: Oak Terrace Country Club, Ambler, Pa.

Method: Treatments were applied on April 8, 1960. Each plot was 60 sq. ft. in size and treatments were replicated 3 times.

Crabgrass started to germinate on April 22, and continued to germinate throughout the summer.

To obtain the per cent control figures, crabgrass infestations in the treated plots were compared to the average infestation in 9 untreated check plots on the same day.

Chemical	Rate	Per Cent Crabgrass Control June 15	Aug. 15	Sept. 15
Product				
Tricalcium arsenate + 2,4-D/2,4,5-TP	@ rec. (*)	100	98	75
Tricalcium arsenate	@ rec.	38	18	-24
Chlordane	@ rec.	58	0	29
Chlordane	@ rec.	-39	10	36
Dacthol	@ rec.	100	99	97
Lead arsenate complex	@ rec.	88	29	19
Experimental				
DAC-893	8 lb/A	96	99	98
DAC-893	10 lb/A	100	99	99
DAC-893	12 lb/A	100	100	99
Zytron 1328	15 lb/A	100	98	99
Zytron 1328	20 lb/A	100	100	99
Zytron 1481	15 lb/A	96	93	92
Zytron 1481	20 lb/A	92	96	90
XF-832	3/4 lb/M	96	98	81
XF-832	1½ lb/M	100	99	92
XF-834	3/4 lb/M	77	82	-11
XF-834	1½ lb/M	85	87	79
XF-833	3/4 lb/M	62	51	19
XF-833	1½ lb/M	99	97	87
Check plots	----	26% crab cover	61% crab cover	63% crab cover

(*) as recommended by manufacturer

TABLE II — Comparison of Products and Experimental Materials for Tolerance to Seeds Planted Into Treated Areas.

Location: Amchem Research Farm, Ambler, Pa.

Method: Treatments were applied on May 4 to plots 6 ft. by 20 ft. Bands of seed were spread on May 5, 12, 19 and June 2; 1 day, 1 week, 2 weeks and 4 weeks after treatment.

Estimates of the stand of seeded grasses were made 9 weeks after chemical treatment. During the course of the season, severe stands of foxtail and general broadleaf weeds developed in the area. The foxtail was eliminated with two light applications of DSMA, the small broadleaf weeds were removed with a single treatment of 1½ lb/A 2,4-D amine. The 2,4-D removed most of the clover, so no reading was made on this. The DSMA applied after the observation date, slightly reduced the quality of bent, blue and rye, and in many cases practically eliminated seedling fescue.

10 = normal stand
0 = complete kill

Chemical	Rate	Grass	Stand of Seeded Grasses July 8 Interval after treatment before seeding: 1 day	1 week	2 weeks	4 weeks
XF-832	3/4 lb/M	bent	9	10	10	7
		blue	8	9	9	4
		fescue	8	9	9	4
		rye	10	10	10	7
XF-832	1½ lb/M	bent	10	10	9	6
		blue	10	10	7	6
		fescue	10	10	7	3
		rye	10	10	8	7
XF-834	3/4 lb/M	bent	9	10	8	5
		blue	10	8	8	3
		fescue	10	8	7	3
		rye	10	10	9	7
XF-834	1½ lb/M	bent	10	10	9	6
		blue	9	10	8	5
		fescue	7	10	7	3
		rye	10	10	9	9
XF-833	3/4 lb/M	bent	10	10	9	5
		blue	10	10	9	5
		fescue	10	10	9	5
		rye	10	10	9	8
XF-833	1½ lb/M	bent	10	10	8	5
		blue	10	9	8	5
		fescue	10	7	6	3
		rye	10	10	8	6

Table II (con't)

Chemical	Rate	Grass	Stand of Seeded Grasses July 8 Interval after treatment before seeding 1 day	1 week	2 weeks	4 weeks
Zytron 1328	15 lb/A	bent	0	0	0	2
		blue	0	0	0	1
		fescue	0	0	0	1
		rye	1	2	2	4
Zytron 1481	15 lb/A	bent	4	0	0	0
		blue	2	0	2	0
		fescue	0	0	0	0
		rye	6	7	4	3
Chlordane (product)	@ rec.	bent	10	10	8	4
		blue	10	10	8	3
		fescue	10	10	9	5
		rye	10	10	10	6
Dacthol (product)	@ rec.	bent	0	0	0	0
		blue	0	0	0	0
		fescue	0	0	0	0
		rye	1	2	3	3
Tricalcium arsenate + 2,4-D/2,4,5-TP (product)	@ rec.	bent	6	8	5	2
		blue	1	2	2	1
		fescue	1	2	2	1
		rye	2	2	4	3
Check		bent	10	7	5	2
		blue	8	9	6	2
		fescue	9	7	6	3
		rye	10	10	9	4
Check		bent	10	10	9	5
		blue	10	10	9	3
		fescue	10	10	9	3
		rye	10	10	8	6

TABLE III — Comparison of Products and Experimental Materials for Tolerance to Seedling Grasses.

Location: Amchem Research Farm, Ambler, Pa.

Method: Grasses were seeded on May 5. Treatments were applied on May 26 and June 15. Bands of chemical 18 inches wide were applied to the seedlings with a 6 inch check strip left between the treated bands.

Grasses were mowed first on June 2 and at approximately weekly intervals thereafter.

Seedlings treated May 26 were evaluated June 6 and July 8.
Seedlings treated June 15 were evaluated June 22 and July 8.

10 = normal stand
0 = complete kill

Treated May 26

Chemical	Rate	Turf Injury - Average of Ratings June 6 & July 8					
		Bent	Blue	Fescue	Rye	Clover	Crab
XF-832	3/4 lb/1000	9.5	10	9.5	10	8	5.5
XF-832	$1\frac{1}{2}$ lb/1000	9	10	7	10	5	0
XF-834	3/4 lb/1000	10	10	8.5	10	5	0
XF-834	$1\frac{1}{2}$ lb/1000	10	10	8	9.5	1	0
XF-833	3/4 lb/1000	10	10	10	10	7.5	4
XF-833	$1\frac{1}{2}$ lb/1000	9.5	10	9.5	10	6.5	0.5
Zytron 1328	15 lb/A	5.5	5.5	3.5	7	5.5	1
Zytron 1481	15 lb/A	7.5	9.5	9	10	10	10
Chlordane (product)	@ rec.	10	10	9.5	10	10	10
Dacthol (product)	10 lb/A	9.5	10	9	9.5	10	9.5
Tricalcium arsenate + 2,4-D/ 2,4,5-TP (product)	@ rec.	6	3	8.5	9.5	1.5	3.5

Table III (con't)

Treated June 15

Chemical	Rate	Turf Injury - Average of Ratings June 22 & July 8					
		Bent	Blue	Fescue	Rye	Clover	Crab
XF-832	3/4 lb/1000	9.5	10	7	10	9	4
XF-832	1½ lb/1000	9.5	10	6	9.5	7	1.5
XF-834	3/4 lb/1000	10	10	6.5	9.5	9.5	0.5
XF-834	1½ lb/1000	10	10	4.5	9.5	8.5	0
XF-833	3/4 lb/1000	10	10	10	10	9.5	7
XF-833	1½ lb/1000	10	10	10	10	8.5	6
Zytron 1328	15 lb/A	3	8	5	10	9.5	9.5
Zytron 1481	15 lb/A	6.5	10	9.5	10	10	10
Dacthol (product)	10 lb/A	8.5	10	10	10	10	10
Tricalcium arsenate + 2,4-D/2,4,5-TP (product)	@ rec.	8.5	7	2.5	7	1	2

THE EFFECTIVENESS OF COMBINATIONS OF PLOW-DOWN, PRE-EMERGENCE AND AND POST-EMERGENCE TREATMENTS FOR QUACKGRASS CONTROL, 1960 RESULTS.

Stanford N. Fertig 1/
(A Summary Report)

INTRODUCTION:

The most prevalent grass problem on New York farms is Quackgrass (*Agropyron repens*) In small grains, corn, potatoes and vegetable production, it is a menacing problem. Heavy infestations compete vigorously for moisture and nutrients, resulting in losses in yield and quality.

EXPERIMENTAL METHOD AND PROCEDURE:

The herbicides listed in Table 1 were applied as plow-down and pre- and post-emergence treatments in the spring of 1960. As indicated in the table, all plots received a plow-down treatment. These were followed by pre- or post-emergence treatments to the corn.

The chemicals were applied to vigorously growing Quackgrass (4 to 6 inches tall) on May 6. The areas were plowed on June 3 and planted to corn on June 4.

The pre-emergence treatments were applied on June 8 and the post-emergence treatments on June 28.

All treatments were replicated 4 times and all chemicals applied in 30 gallons of water per acre.

In all instances, one-half of each plot was cultivated two times. The first cultivation was 3 weeks after planting and the second, 7 weeks after planting.

RESULTS AND DISCUSSION:

The stand of Quackgrass was markedly reduced by all chemicals and combinations of treatment, particularly when combined with two cultivations. The stand counts (Table 2) show the added effectiveness of two cultivations in reducing the stand of Quackgrass.

Based on stand counts, yields of silage corn and observations during the growing season the most promising treatments were 3, 4, 7, 8, 11, 12 and 13.

The competitive effect of heavy stands of Quackgrass on corn yields are shown in Table 2. The average yields are below normal due to late planting (June 4) and an early harvest (September 19). However, the differences in yield are significant and show the competitive effect of Quackgrass on corn. The 1960 growing season was exceptionally cool but with ample moisture.

1/ Professor of Agronomy, Cornell University, Ithaca, N. Y.

Table 1. Chemicals and Combinations Used as Spring Treatments for Quackgrass Control, 1960.

Treatment No.	Chemical before Plowing	Rate/A. lbs. A.E.	Chemical Pre-emergence	Rate/A. lbs. A.E.	Chemical Post-emergence	Rate/A. lbs. A.E.
1	Amitrol-T	2.0	Simazine	2.0		
2	Amitrol-T	4.0	Simazine	2.0		
3	Amitrol-T	2.0	Atrazine	2.0		
4	Amitrol-T	4.0	Atrazine	2.0		
5	Atrazine	2.0				
6	Atrazine	3.0				
7	Atrazine	4.0				
8	Atrazine	2.0	Atrazine	2.0		
9	Atrazine	2.0	Atrazine	1.0		
10	Atrazine	1.0	Simazine	1.0		
11	Atrazine	2.0			Atrazine	1.0
12	Atrazine	2.0			Atrazine	2.0
13	Amitrol-T	2.0				
	plus					
	Atrazine	2.0				
14	Check					

Table 2. Stand Counts and Silage Yields from Spring Applications of Herbicides for Quackgrass Control.

Treatment No.	Average number of Quackgrass shoots/sq. ft.* cultivated	not cultivated	Yield of silage corn Tons/A. 75% moisture** cultivated	not cultivated
1	2.1	17.5	18.9	14.9
2	3.0	8.4	21.2	16.2
3	2.3	7.0	18.0	18.7
4	1.4	5.0	19.3	21.4
5	1.0	2.6	16.2	14.2
6	2.0	1.0	18.7	18.4
7	0.8	0.7	19.4	18.0
8	0.7	4.3	17.1	18.2
9	1.7	3.5	16.7	21.6
10	2.0	11.0	17.1	16.6'
11	2.5	6.0	18.4	18.0
12	1.4	2.6	20.2	18.2
13	0.8	0.3	16.9	13.9
14	14.4	22.0	5.9	2.9

*Average of 3 - 2 sq. ft. quadrat counts per plot.
**All plots corrected for stand. The yield is based on the same number of plants per plot.

SUMMARY:

The combination of herbiciees used in this study was the most promising Quackgrass control treatments to be investigated over the past 10 years. The combination of plow-down and pre- or post-emergence applications resulted in very marked reductions in Quackgrass stands and provided seasonal control of a wide range of broad-leaved weeds and annual grass species.

Note: A mimeographed copy of the complete paper is available from the author.

QUACKGRASS CONTROL

S. M. Raleigh[1]

The quackgrass control studies reported in this paper were conducted under very adverse conditions. There were 2.58 inches of rain from October 22 to October 28, 1959, and 5.85 inches from May 8 to May 24, 1960. The plots were plowed May 27 but not planted until June 7, with a total of 7.30 inches or rain between treatment and planting.

The results given in Table I are rated with 0 given to fall plowing without chemical treatment and a rating of 10 being complete control. No treatments give complete control. There were 4 replications in each treatment. A strip, 20 feet wide, in each plot was plowed and another strip was disked on October 22 before any chemicals were applied. The disking on October 29, was immediately after the last fall treatment. Another 20 foot strip was plowed November 13. The spring treatments were applied May 5 and another 20 feet were plowed that day. The fall disked area and another 20 foot strip was plowed May 27, 1960.

Heavy disking in the fall was rather effective in controlling quackgrass without chemical treatment. The quackgrass roots were all near the surface of the soil. Plowing November 13 was much better than October 22 without chemical treatment. Amitrol-T (ACP 569) at 4 pounds per acre applied October 29 was much better than 6 pounds Amitrol-T applied October 22, apparently because of the slow drizzly rain. Fall treatments plowed May 5 were generally much better than May 27 plowing. This is especially true of Atrazine, also Atrazine plowed the day of treatment in the spring (May 5) was poorer than plots plowed May 27.

In Table II, the results are given where plots were logged sprayed May 4, 5, and 6, 1960, when the quackgrass was 4-6 inches tall, also the results are given with Atrazine applied pre and post emergence to the quackgrass. All plots were plowed May 27 and planted June 7.

The excessive amount of rain appeared to reduce the effectiveness of dalapon and Amitrol-T. The benzac plots were much poorer than expected. A commercial field near these plots treated with Amitrol-T at 4 pounds in mid April, plowed and

1. Professor of Agronomy, Penn State University.

planted before these heavy rains, gave nearly 100 per cent control of quackgrass.

Atrazine was more effective than simazine when applied at the same rates. Some of fenac derivatives appear to be somewhat better than fenac.

Atrazine applied after plowing, both pre-emergence and post-emergence to quackgrass reduced the quackgrass slightly but was not very effective.

Plowing, preparing, seedbed, and planting the same day, coupled with good cultivation is very essential with nearly all chemicals for good quackgrass control.

Table I

Fall and Spring applications of herbicides
with several cultural dates
University Park, Pennsylvania

Ratings

(0, no control; 10 complete control)

Chemical	When Applied	Rate (lb/ac)	Plowed Oct 22	Plowed Nov 13	Plowed May 5	Plowed May 27	Disked Oct 29 Plowed May 27	Disked Oct 22 Plowed May 27
Atrazine	Oct 22	4	4.5	5.75	7.25	6.25	8.0	8.0
Atrazine	May 5	4	6.0	7.5	5	8.75	9	9
Atrazine & Amitrol-T	Oct 22	2 + 2	1.75	4.5	7.0	5.75	7.25	7.3
Atrazine & Amitrol-T	May 5	2 + 2	4.75	5.25	6.25	6.75	8.25	7.0
Amitrol-T	Oct 22	6	.75	4.0	4.75	4.25	4.75	4.0
Amitrol-T	Oct 22	4	.75	3.5	5.25	4.25	5.5	5.0
Amitrol-T	Oct 29	4	.75	4.25	7.0	6.75	6.25	6.3
Amitrol-T	May 5	4	2.5	4.5	5.5	4.75	5.75	6.67
Amitrol-T	Oct 22	2	.75	2.5	4.25	3.25	4.75	4.3
Amitrol-T	May 5	2	1.25	2.75	5.25	5.25	6.3	6.3
Dalapon	Oct 22	3.3	1.25	2.75	2.25	2.0	4.5	4.5
Dalapon	May 5	3.3	1.25	2.5	2.5	3.0	5.0	5.0
Dalapon	Oct 22	6.6	1.25	3.0	2.75	2.75	4.25	4.5
Dalapon	May 5	6.6	2.0	3.0	5.0	5.50	6.0	6.25
ACP-673A	Oct 22	4	2.0	5.25	5.0	4.25	6.25	7.0
ACP-673A	May 5	4	4.0	7.0	4.0	6.25	7.75	8.0
ACP-673A	Oct 22	2	.75	3.5	2.75	2.75	4.5	4.5
ACP-673A	May 5	2	1.0	3.75	3.75	4.5	6.5	6.5
ACP-675	Oct 22	4	2.5	4.5	4.75	4.75	7.0	7.0
ACP-675	May 5	4	1.5	4.0	3.75	4.0	6.25	6.25
ACP-816A	Oct 22	4	2.0	4.0	4.5	3.75	5.0	5.0
Check			0	1.25	1.75	1.5	3.25	3.0

Table II. The control of quackgrass with spring applications of herbicides

Chemicals			Ratings			
constant	rate (lb/ac)	logged	(0, no control; 10 complete control)			
		Rate (lb/ac)	22.2	11.1	5.55	2.77
		Dalapon	6.0	4.50	1.75	0
		German Dalapon	6.0	4.25	1.75	0
		Rate (lb/ac)	8	4	2	1
		Atrazine	9	8.25	7.0	4.5
		Simazine	8	6.5	3.75	1
		Amizine	8	6.25	2.75	1.0
		Amitrol-T	8.25	7.0	4.25	2.5
		Benzac	5.25	3.5	1.5	.25
		Fenac	8.25	7	4.25	.75
		ACP-822	9	7.67	5	1.3
		ACP-823	8.75	7.25	3.75	.75
		ACP-848	9	7.75	4.5	1
		Hercules 7442	3.0	1.25	.25	0
Fenac	1	ACP-655	1	1	1	1
Amitrol-T	2	Atrazine	9	9	8.5	7
Amitrol	1	Atrazine	9	9	8.25	7
Atrazine	2	Amitrol T	8.75	8.50	7.5	6.50
Atrazine	1	Amitrol T	8.5	7.5	6.25	5.25
		Rate (lb/ac)	0	1	2	4
Amitrol-T	2	Atrazine June 9	2.5	4.75	4.75	5.50
Amitrol-T	2	Atrazine June 17	2.5	4.75	4.50	5.50
Amitrol-T	1	Atrazine June 9	2.0	3.25	3.25	5.0
Amitrol-T	1	Atrazine June 17	2.0	3.25	3.25	5.25

THE EFFECTS OF CHEMICAL AND CULTURAL TREATMENTS ON THE FOOD RESERVES OF QUACKGRASS RHIZOMES[1]

Homer M. LeBaron and S. N. Fertig[2]

INTRODUCTION

The primary factors which contribute toward making quackgrass one of our most noxious weeds of cultivated land are the ability of its mass of branching underground stems to maintain itself as a perennial weed and the fact that every joint of the rhizome is capable of producing new growth. Thus it is obvious that methods of control or eradication of quackgrass must be concerned primarily with the rhizomes.

In view of the great amount of interest and effort that has been extended to the control of this pest, it is somewhat surprising that few studies have been made on the rhizomes themselves. Of those reports in which the effects of treatments on the rhizomes have been investigated, relatively few are applicable to modern methods of quackgrass control. Thus, a more complete knowledge of the physiology of the quackgrass rhizome and the effects of modern control recommendations on its survival and growth would be very beneficial in aiding future investigations and in the interpretation of results.

The basic purpose and objectives of this investigation have been pointed out (1), and are based on the assumption that control or eradication of quackgrass is intimately associated with the depletion of its food reserves and the destruction of its perennial organs.

MATERIALS AND METHODS

This experiment was carried out with a uniform stand of quackgrass on a Mardin silt loam soil at the Mount Pleasant Agronomy Research Farm near Ithaca, N.Y. The area had been in sod the previous year and was largely taken over by quackgrass.

Although this study was a continuation of the 1957-59 experiment (1), it was enlarged to include several additional herbicides which had shown promising results for the control of quackgrass in other trials during the 1958 season. Because of very poor results obtained in the first experiment with chlorinated benzoic acid, it was not investigated further. The factor of nitrogen differential was also not continued because of its relatively minor effect in the first experiment. Since only fallow and spring plowing accompanied by spring chemicals continued to result in lower levels of underground food reserve and satisfactory control throughout the

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[1]This includes part of the work done on the Ph.D. study at Cornell University.

[2]Plant Physiologist, Virginia Truck Experiment Station, Norfolk, Va. and Professor of Agronomy, Cornell University, Ithaca, N.Y., respectively.

growing season in the 1957-59 study, fall treatments were not included in the 1959-60 experiment.

The experimental design of the treatments applied was a 3 x 6 split-plot factorial as follows:

Whole plots---Cultural treatments
A - Plow
B - Fallow
C - No cultivation
Split plots---Chemical treatments
1 - Atrazine
2 - Simazine
3 - Amitrol-T
4 - Fenac
5 - Dalapon
6 - No herbicide

All possible combinations of the treatments were replicated four times, making a total of 72 plots.

The herbicides were all applied on May 16, 1959 at the rate of eight lbs. per acre in 30 gallons of water. All plots except those which were to receive no cultural treatment were plowed on June 2, 1959. The plots to be fallowed were disked or harrowed with a spring-tooth harrow frequently during the growing season to prevent growth and photosythesis.

Samples of quackgrass rhizomes were taken periodically for laboratory analysis according to the following schedule:

June 15, 1959
August 5, 1959
September 10, 1959
November 10, 1959
May 10, 1960

A steel cylinder having an area of one square foot was used to obtain the samples. An area in each plot which had not been previously sampled was selected at random and all weeds and topgrowth of quackgrass was removed. The cylinder having sides constructed of 3/8 inch thick steel and 12 inches high, with a one inch steel plate top, was placed over this area and pounded into the soil to a depth sufficient to obtain all rhizomes. After all soil and foreign material were removed, the clean rhizomes from each plot were placed in a paper bag and dried in a forced-air oven at 70° C. After drying, the rhizomes were weighed, ground and stored in airtight bottles until analysis was to be made. They were then redried, mixed thoroughly and analyzed for carbohydrate content.

The procedure used in the quantitative determinations of carbohydrate was the same as previously reported for the 1957-59 experiment (1), which was based on a colored compound formed by the interaction of fructose and resorcinol.

On the basis of the rhizomes obtained from one square foot of soil per plot on each sampling date, the yields of rhizomes and fructose per unit area, as well as the concentration of total fructose, were determined. This paper deals only with the main effects of and interaction between chemical and cultural treatments on the fructose content of the quackgrass rhizomes.

RESULTS AND DISCUSSION

The main effects of both cultural and chemical treatments, as well as their interaction, resulted in significant differences in the rhizome reserves at the one per cent level throughout the experiment.

Main effects of cultural treatments:

The main effects of the cultural treatments on the carbohydrate content of quackgrass rhizomes are given in Table I.

Both spring plowing and fallow resulted in rapid decreases of about 50 per cent in fructose content. The single spring plowing treatment continued to hold the rhizomes near this low level of carbohydrates until late autumn, when sufficient regrowth had taken place to again accumulate photosynthate in the underground organs. It still showed a 15 per cent reduction over the uncultivated plots, but this difference was no longer significant. The data from the final sampling the following spring showed the fructose content from the plowed rhizomes to be almost equal to the uncultivated rhizomes.

On the other hand, the continuous fallow treatment continued to deplete the rhizomes of their stored food, resulting in depletions of about 70 per cent toward fall of 1959 and 74 per cent by May 10, 1960.

The data on fructose content over all sampling dates show that the fluctuations in the per cent fructose of normal untreated rhizomes are small, with the reserves remaining at a high level from early summer to late autumn. Winter respiration and early spring regrowth, however, caused a decrease in the fructose content of about 50 per cent as seen from the data of May 10, 1960.

Main effects of chemical treatments:

The main effects of the herbicides on the carbohydrate content of quackgrass rhizomes are given in Table II.

Atrazine was most striking in its effect on the underground reserves, not only based on its rate and extent of reduction but also on its permanency. It resulted in a very sharp and early decrease of 71 per cent in the fructose content at the first sampling date. Its effect continued to increase slowly until the carbohydrates had been depleted by 83 per cent by late autumn and 90 per cent by the following spring.

The effect of Simazine on the fructose content was somewhat slower, resulting in a decrease of 54 per cent on June 15, but was almost equal to

Table I Main Effects of Cultural Treatments on the Fructose Content of Quackgrass Rhizomes at all Sampling Dates in the 1959-60 Experiment

Sampling Date	Cultural Treatments, Means (per cent) Homogenous Series and Per Cent Reduction from each Treatment			Levels of Significance (per cent)	Untreated Mean
	Fallow	Plow	No cultivation	1	
June 15 1959	10.7	12.3	23.4		39.6
	(54)	(47)		5	
	Fallow	Plow	No cultivation	1	
Aug. 5 1959	10.6	13.7	24.4		41.9
	(57)	(44)		5	
	Fallow	Plow	No cultivation	1	
Sept. 10 1959	6.5	12.2	22.7		40.6
	(71)	(46)		5	
	Fallow	Plow	No cultivation	1	
Nov. 10 1959	7.7	19.6	23.0		38.0
	(67)	(15)		5	
	Fallow	Plow	No cultivation	1	
May 10 1960	3.8	14.2	14.8		19.7
	(74)	(4)		5	

Table II Main Effects of Herbicide on the Fructose Content of Quackgrass Rhizomes at all Sampling Dates in the 1959-60 Experiment

Sampling Date	Herbicides, Means (per cent), Homogenous Series and Per Cent Reduction from each Treatment						Levels of Significance (per cent)	Untreated Mean
	Atr.	Sim.	Ami.	Fen.	No herb.	Dal.	1	
June 15 1959	6.0	9.3	15.8	20.3	20.4	21.9		39.6
	(71)	(54)	(23)	(0)		(-7)	5	
	Atr.	Sim.	Ami.	Fen.	No herb.	Dal.	1	
Aug. 5 1959	6.3	7.8	13.5	22.2	23.8	23.9		41.9
	(74)	(67)	(43)	(7)		(0)	5	
	Atr.	Sim.	Ami.	Dal.	Fen.	No herb.	1	
Sept. 10 1959	4.1	4.8	15.9	17.1	18.0	23.0		40.6
	(82)	(79)	(31)	(26)	(22)		5	
	Atr.	Sim.	Ami.	Fen.	Dal.	No herb.	1	
Nov. 10 1959	4.8	6.6	18.6	20.8	21.0	28.8		38.0
	(83)	(77)	(35)	(28)	(27)		5	
	Atr.	Sim.	Ami.	Dal.	Fen.	No herb.	1	
May 10 1960	1.7	9.7	11.1	13.1	13.2	16.9		19.7
	(90)	(43)	(34)	(23)	(22)		5	

Legend:

Atr. - Atrazine
Sim. - Simazine
Ami. - Amitrol-T
Fen. - Fenac
Dal. - Dalapon
No herb. - No herbicide

Atrazine by September 10 when the carbohydrate depletion reached 79 per cent. The effectiveness of Simazine, however, failed to persist, and by May 10, 1960 the reduction in fructose content was only 43 per cent, or less than 1/2 that of Atrazine. The difference between Atrazine and Simazine was never significant until the final sampling period. However, the fructose content values resulting from the action of both herbicides were significantly lower at the one per cent level during the first four sampling dates than the quackgrass receiving an application of Amitrol-T, Fenac, Dalapon or no herbicide.

Treatment with Amitrol-T showed a small early decrease of 23 per cent on June 15, but it was significant only at the five per cent level. However, its effect increased and resulted in carbohydrates ranging between 31 and 43 per cent lower than the untreated plots at the later sampling dates.

Applications of Fenac or Dalapon showed no significant effects on carbohydrate content until fall. By September 10, they resulted in decreases of 22 and 26 per cent, respectively, which were significant only at the five per cent level. Samples collected in late autumn showed only slightly greater depletions which were highly significant compared to the quackgrass receiving no herbicide. The effects of Fenac and Dalapon decreased slightly during the winter and following spring, showing significant differences only at the five per cent level from the May 10, 1960 data. Fenac and Dalapon were never significantly different from each other. Amitrol-T resulted in significantly lower fructose content than Fenac or Dalapon only at the first two sampling dates.

Interaction between cultural and chemical treatments:

Although the interaction between cultural and chemical treatments on the fructose content of quackgrass rhizomes was highly significant at all sampling periods and any trends throughout the season will be discussed, the data from only one period (November 10, 1959) are presented in Table III.

An explanation for the significant interaction can be given by comparing the effects of the various herbicides with each cultural treatment. The most striking case is the treatment in which no cultivation was applied. The greatest depletion of food reserves did not occur in the fallowed or plowed quackgrass as might be expected. Atrazine actually enhanced the depletion of carbohydrates when no disturbance of the soil took place, though the difference was not usually significant. With the exception of Atrazine, the herbicides induced a relatively minor depletion throughout the season when not followed by a cultural treatment. There was some indication toward the end of the 1959 season that the Simazine application without cultivation was equal or superior to the same application with cultivation. However, by May 10, 1960 the Simazine plots under no cultivation or single plowing failed to show significantly lower fructose content values than quackgrass receiving no herbicide or cultivation. Until the May, 1960 sampling, the differences between Atrazine and Simazine under the various cultural treatments were never significant at the one per cent level, although they were always significantly lower than the uncultivated check.

Table III Interaction Between Cultural and Herbicidal Treatments on the Fructose Content of Quackgrass Rhizomes (sampled on November 10, 1959)

Treatments Cultural	Herbicide	Significant at 1%	Mean (% fructose)	Significant at 5%	Per cent Reduction
No cultivation	Atrazine		0.8		98
Fallow	Simazine		3.4		91
Fallow	Atrazine		5.4		86
Fallow	Fenac		5.4		86
No cultivation	Simazine		6.9		82
Fallow	Amitrol-T		8.0		79
Plow	Atrazine		8.2		78
Fallow	Dalapon		9.5		75
Plow	Simazine		9.6		75
Fallow	No herbicide		14.2		63
Plow	Dalapon		19.9		48
Plow	Amitrol-T		20.6		46
Plow	Fenac		25.2		34
No cultivation	Amitrol-T		27.3		28
No cultivation	Fenac		31.7		17
No cultivation	Dalapon		33.5		12
Plow	No herbicide		34.1		10
No cultivation	No herbicide		38.0		

Another effect of Atrazine that should be pointed out is a characteristic trend over all sampling dates under the superimposed cultural treatments. Under continuous fallow, Atrazine resulted in a sharp and early decrease of 86 per cent on June 15, and showed little deviation from this value throughout the season. A decrease of 86 per cent was still maintained on November 10. The single spring plowing following treatment gave about the same early value, showing 84 per cent depletion of fructose on June 15. Instead of remaining constant or increasing in effect, the carbohydrate content increased slightly, showing a reduction of only 78 per cent on November 10. When no cultivation followed the application of Atrazine, samples collected on June 15 showed a reduction of 85 per cent, indicating that essentially all of this early loss of carbohydrates could be induced without any cultural treatment. However, the fructose content of the uncultivated rhizomes continued to decrease gradually throughout the season, resulting in almost complete depletion of 98 per cent by November 10.

The effect of Simazine on the fructose content of uncultivated rhizomes also tended to change from a 61 per cent to an 84 per cent reduction by September 10, 1959. However, this effect was reduced sharply during the winter and the following spring, showing only a 24 per cent decrease on May 10, 1960. Simazine plus spring plowing gave an early sharp decrease of 87 per cent which dropped to 75 per cent by November 10, 1959 and 37 per cent by May 10, 1960. Simazine plus fallow, on the other hand, tended to increase the carbohydrate depletion and was always superior to the uncultivated quackgrass treated with Simazine, showing a reduction of 92 per cent by September 10, 1959 which remained constant throughout the remainder of the experiment.

Applications of the other herbicides did not induce very large reductions in the fructose content of rhizomes unless followed by tillage treatments. Dalapon and Fenac with no cultivation showed early minor decreases of 24 and 23 per cent, respectively, but the carbohydrates gradually increased until the rhizomes showed only 12 and 17 per cent lower fructose values on November 10 than the untreated checks. By May 10, 1960 Fenac and Dalapon under no cultivation showed fructose content values equal to or higher than the quackgrass receiving no treatment. At no sampling date were these differences significant at the one per cent level.

Amitrol-T with plowing or no cultivation gave significant reductions over the untreated checks at all except the final sampling date. Without cultivation, the reduction in fructose content amounted to 57 per cent by August 5, 1959. However, the effect decreased toward the end of the season, showing only a 28 per cent depletion on November 10, 1959 and May 10, 1960. The fructose content values from Amitrol-T plus plowing followed a similar trend, decreasing to a depletion of 72 per cent by August 5, 1959, then increasing again gradually to only a 30 per cent reduction by May 10, 1960.

The effectiveness of Dalapon or Fenac application on the carbohydrate content of quackgrass rhizomes was considerably increased and prolonged when accompanied by the single spring plowing. The spring plowing alone resulted in an early rapid decline of 72 per cent in the fructose content. This deficiency was replenished slowly to September 10, when a 50 per cent reduction remained, and then more rapidly to a 10 per cent reduction on November 10, 1959. By the following spring, the plowed plots receiving no herbicide showed an increase of 26 per cent in the carbohydrate content of the rhizomes compared to the untreated sod plots. This increase in carbohydrate content due to plowing, although non-significant, was apparently caused by a stimulation of new rhizome growth by improving the soil environment and aiding the decomposition of old rhizomes. Dalapon and Fenac applications followed by plowing also resulted in rapid and highly significant decreases in fructose content. However, instead of becoming replenished, the depletion persisted and increased until the September 10 sampling date, when both herbicides showed a reduction of about 70 per cent. The herbicides then began to lose their effectiveness as late fall and early spring regrowth of quackgrass increased the carbohydrate content of the rhizomes. By late fall, Dalapon plus plowing still gave a reduction of 48 per cent, which was significantly superior to the quackgrass receiving either no treatment or a single plowing. The May 10, 1960 data show, however, that Dalapon plus plowing resulted only in a 28 per cent reduction which was not significantly different from the untreated rhizomes, although it was still significantly lower than the plowed quackgrass receiving no herbicide. The effect of Fenac decreased to an even greater extent. Although it gave a significant reduction of 34 per cent compared to the untreated check plots on November 10, 1959, by the following spring, no significant difference was observed. At no sampling period did Fenac plus plowing result in significantly lower carbohydrate content values at the one per cent level than the plowing treatment alone.

SUMMARY AND CONCLUSIONS:

A second experiment designed to study the effects of chemical and cultural treatments on the survival and carbohydrate content of quackgrass rhizomes was conducted from spring of 1959 to spring of 1960. Relationships between the quackgrass control as measured by topgrowth and the effect of treatments on the underground organs were studied.

Although the destruction and control of topgrowth was generally accompanied by a reduction in rhizome reserves, the relationship was subject to wide variations.

While Dalapon resulted in complete top-kill and suppression of regrowth during most of the growing season in both experiments, the food reserves of quackgrass rhizomes were never reduced by much more than 25 per cent.

Simazine, on the other hand, showed very slow and incomplete destruction of the quackgrass foliage while resulting in depletions of about 80 per cent in underground carbohydrates.

Atrazine was the most severe herbicide both on topgrowth and rhizome reserves, resulting in a rapid and extensive depletion of carbohydrates. It was the only treatment which continued to show no regrowth and to decrease the food reserves in the rhizomes throughout the winter and following spring.

Fenac, which resulted in carbohydrate reductions equal to Dalapon, gave very little destruction or suppression of regrowth.

Amitrol-T was intermediate in its effect on both food reserves and topgrowth. It resulted in good kill and regrowth suppression throughout most of the growing season. Some stubble survived, however, and regrowth occurred in late fall.

Spring plowing resulted in a large initial reduction in food reserves which persisted until sufficient regrowth had occurred to replenish the underground organs.

Continuous fallow, on the other hand, continued to deplete the rhizome reserves throughout the experiment.

Interactions between chemical and cultural treatments on the rhizome reserves are discussed.

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Further studies on a growth inhibitor from *Agropyron repens* (Quackgrass)+

C. W. LeFevre and C. O. Clagett++

At the 1960 Northeastern Weed Control Conference (1) we presented a brief literature review and a preliminary report on the concentration of a growth inhibitor from quackgrass. In this presentation we are summarizing our 1960 progress on the isolation of the inhibitor(s).

Experimental Procedure

Extraction. In order to determine the rate of water extraction of the inhibitor in ground rhizomos a 40 x .8 cm. column containing 4 gm of the material mixed with asbestos was prepared. Water was leached through the column and the leachate was collected in 5 ml. portions with a G.M.E. fraction collector. The volume of water necessary for complete elution is found in figure 1.

This method of elution was so effective that it was modified and used for further extractions. A few grams of ground plant material were placed in a sintered glass crucible containing a layer of cellite over the porous glass. This was leached under vacuum into a flask maintained at 50°C so that extraction and evaporation was accomplished in one operation.

Paper Chromatographic Separation

The concentrated extract was streaked on S & S 470A filter paper and irrigated with a Whatman No. I wick. Solvent systems were prepared as follows:

(1) Ethanol-water (80-20 v/v)
(2) 2-butanone-T bulanol-water (50-30-20 v/v).
(3) N-butanol saturated with water;
(4) Phenol-Water (80-20 v/v;
(5) Dioxane-Water (75-25 v/v; and
(6) Dioxane-Methanol Acetone-Water (30-30-20-20 v/v.

The papers were sectioned, the sections eluted, and the elulates tested for activity. The assay involved measuring the growth of three replications of 5 alfalfa seeds in 5 ml beakers containing filter papers wetted with .5 ml test solution. The eluate was concentrated and recromatographed using other solvent systems.

+ Progress report on Experiment station projects N.E. 42-1375 and 1218.

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Column Separation: Cellulose. A 24 x 1 7/8 inch column packed with Whatman standard grade cellulose powder was used as a second system. The column was packed wet, the sample placed on top of the packed powder and 80% Ethanol was passed through the column. The fractions were collected with a G.M.E. fraction collector using a Packard model 235 U.V. monitor to detect the cuts.

Column Separation: Silicic acid. The most recent attempt at purification has been with Mallinckrodt Silicic acid. The silicic acid was deactivated as described by Jarboe (2) in 1960. Twelve grams were sulurried in chloroform and added to a jacketed 15 mm x 450 mm column and the $HCCl_3$ was drained to the top of the column. The residue from the active sections of 8 chromatogram papers was adsorbed to a glass wool plug wetted with distilled water. A second plug was used to adsorb remaining residue. A gradient system of chloroform and methyl alcohol was used to elute the column. 500 ml methanol containing .5 ml conc NH_4OH was dripped into 300 ml $HCCl_3$ in a closed mixing chamber, thus the elulion began with 100% $HCCl_3$ and became logarithmetically diluted with the ammoniated methyl alcohol. The fractions were again collected with the G.M.C. fraction collector.

Adsorption on Activated Carbon. The extract from one gram of quackgrass was mixed with 5 grams Acetic acid-washed Norite, and filtered with a Buchner funnel. The filtrate was eluted with methanol and with methanol containing ammonia and the three fractions were tested for activity.

Results & Discussion

The inhibition from four grams of quackgrass was completely eluted with 30 ml of water (Table I). A brownish yellow color was associated with the inhibiting fractions.

Table I. Water extraction of the inhibitor from ground rhizomes in a column.

Ml. Water	5	10	15	20	25	30	35	40	80
MM growth of seedlings	00	00	00	9	24	50	45	61	49
% Inhibition	100	100	100	83	53	3	14	15	5

An increase in growth in the 40 ml fraction indicates the possibility of stimulation from very small quantities of the inhibitor. Data from other experiments, particularly on column work have indicated stimulation. Helgeson (3) reported such effects. More data with pure compounds will be needed to establish this point.

Ethyl alcohol extractions were less efficient than water extractions in removing the inhibitor(s).

Two solvent systems (No. 1 and No. 2) were found to give satisfactory results when run in either an ammonia or acetic acid atmosphere. The ammonia atmosphere was preferred because the solutions extracted were neutral and did not require pH alteration for the assay.

Migration values in the butanone, T-butanol, Water System (#2)

A complete analysis of a chromatogram showed several inhibitory regions. One of these (Area A in figure 1) was present only in certain harvests of quackgrass. Fertility and organic content of the soil may be factors in the occurrence of this inhibitor. An assay of origional extract showed nearly complete inhibition whereas extracts of quackgrass from earlier harvests inhibited in the 50% range with little inhibition in the A section. The inhibititor reported in our early experiments is extracted from areas corresponding to E and F in figure 1. In some instances almost total inhibition was found in the upper area with less inhibition in the E-F area.

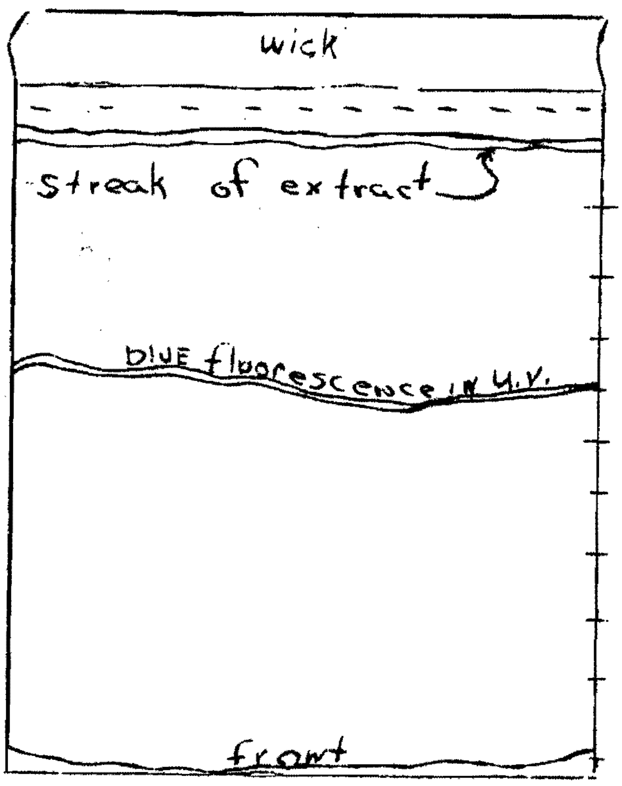
The upper inhibition was not adsorbed by Norite using batch or column processes though this treatment took out all the color. It was at first thought this inhibition was due to mineral salts since they should have low migration values in the solvent systems used in this study.

The nature of the inhibition from this area has not been explored since it was only recently observed.

The assay of quackgrass taken from New York, Vermont, West Virginia, and Pennsylvania, and grown at State College showed a large variation in inhibition in preliminary trials. Further study will be made of this variation and inhibition tests will be made with quackgrass of a single clone grown at various levels of fertility.

When the active material from the 2-butanone-T-butanol-Water system was rechromatographed on a cellulose column using 80% Ethanol as the solvent impure crystals were observed in an active fraction. Further purification will be necessary before chemical characterization is attempted. Recently silica gel columns have given very encouraging results but more work will have to be done to evaluate this procedure.

Figure 1. Chromatogram of quackgrass extract with 2-butanone, T-butanol, and Water (50-30-20 $^{v}/v$) showing areas of migration of inhibitor.



Section	% Inhibition
A	48
B	25
C	21
D	27
E	42
F	56
G	21
H	17
I	8
J	5

Summary and Conclusions

Of the solvent systems used only two were satisfactory for separation. The remaining systems either destroyed the inhibitor during partition or were themselves inhibitory in the small amounts adsorbed to the filter paper. Paper chromatography was not suitable for final isolation, because an inert residue is always found in the concentrate even with well washed papers. We hope to overcome this difficulty through the use of silica gel columns. Paper chromatographic evaluation has been useful in assaying the inhibitor concentration of quackgrass from different origins.

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PRELIMINARY RESULTS ON THE USE OF CHEMICALS FOR NUTGRASS CONTROL IN FIELD CROPS

Stanford N. Fertig 1/
(A Summary Report)

INTRODUCTION:

During the past 10 years, Nutgrass has spread widely on New York farms and must be considered as a major weed problem in every agricultural county in the state.

The generally held idea that Nutgrass is a problem only on wet or poorly drained soils is in error. Many of the most serious infestations are on well and moderately drained soils of high fertility and on many of the better farms.

The control of Nutgrass in growing crops by cultural methods is not economically feasible or effective. Cultural methods tend only to spread the tubers to adjacent uninfested areas.

EXPERIMENTAL METHOD AND PROCEDURE:

The experiment was located on the Griswold Farm, Cortland County, N. Y. The area had been seeded to millet during the first week of June, 1959. On June 15, the selected plot area was fitted using a spring-tooth harrow. On June 23, the chemicals listed in Table 1 were applied as incorporated soil treatments. The plots were harrowed twice (to a depth of 4 inches) immediately after the chemicals were applied.

The post-emergence treatments (Table 1) were applied to plots which had no cultural treatment. The millet and Nutgrass averaged five inches tall at the time of application.

The soil incorporated treatments were replicated two times and the post-emergence treatments replicated four times.

RESULTS AND DISCUSSION:

Based on observations and stand counts, the Eptam and R-1607 at the 6-pound rate were the most effective of the soil incorporated treatments in reducing the stand of Nutgrass.

The R-2060 and R-2061 and the 2- and 4-pound rates of Atrazine were least effective. However, the stand of Nutgrass was markedly reduced.

The 6- and 8-pound rates of Atrazine as incorporated treatments were no more effective than the 4-pound rate of Eptam or R-1607.

Based on the stand counts, all rates of Atrazine were effective in reducing the stand of Nutgrass when applied as post-emergence sprays. The 2-pound rate would be considered less than desirable, but the reduction in

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Nutgrass stand was significant compared to the check (Table 1).

Table I. Chemicals Used as Soil Incorporated and Post-emergence Treatments, Rates per Acre and Stand Counts on Nutgrass.

Treatment No.	Chemical Used as Incorporated or Post-emergence	Rate/A. lbs. A.E.	Average number of Nutgrass Plants, sq. ft.* August 6, 1959
Incorporated Treatments			
1	Eptam	4.0	5.8
2	Eptam	6.0	2.8
3	R-1607	4.0	6.1
4	R-1607	6.0	2.8
5	R-2060	4.0	16.2
6	R-2060	6.0	9.2
7	R-2061	4.0	16.2
8	R-2061	6.0	15.7
9	Atrazine	2.0	21.6
10	Atrazine	4.0	12.7
11	Atrazine	6.0	7.7
12	Atrazine	8.0	6.3
13	Check	0.0	60.0
14	Check	0.0	55.7
Post-emergence Treatments			
1	Atrazine		12.4
2	Atrazine		2.8
3	Atrazine		2.1
4	Check		54.5

*Average of 3 - 2 sq. ft. quadrat counts per plot.

Note: A mimeographed copy of the complete paper is available from the author.

DATE OF BERRY HARVEST AS IT AFFECTS SEED MATURITY OF HORSENETTLE (Solanum carolinense)

Thomas F. Tisdell[1], Richard D. Ilnicki[2] and William F. Meggitt[3]

ABSTRACT

Horsenettle berries were collected from August 1959, through March 1960, at monthly intervals in one location, in order to determine seed maturity by germination tests. Seed harvested in August exhibited no initial or subsequent germination. Seed harvested in September, October, November and January had very poor initial germination, which improved after several months of storage. Seed obtained from berries collected in December had a low per cent germination, that remained unchanged over a period of six months. Seeds collected in February and March had good initial germination.

Subsequent studies were designed to determine the age of the seed and its effect on germination. Individual berries were identified by their flowering dates. Berries were also collected from two different sets of plants. One set had been started with rootstocks from New York State, while the other set was native to New Jersey. Seeds collected, on six different dates, from 45 to 135 days after the opening of flowers showed very poor initial germination, while seeds collected 160 days after flowering had a somewhat higher initial germination. When the seed from the first and second collections was again tested in November the germination had not changed. The seed from the third and fourth collections showed a slightly improved germination. At this time the New York seed from the sixth collection was found to have a considerably higher germination than that observed initially. In most cases of low germination the number of hard seeds is high; therefore, it seems that a large number of these ungerminated seeds are still viable. Most of these seeds imbibe water. Any dormancy phenomenon which exists is probably centered in the embryo. This seed dormancy is apparently broken by exposure to over-wintering conditions or to several months of dry storage. The results of these germination studies together with other measurements, suggests the possible existence of different strains of horsenettle.

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TWO YEAR SUMMARY OF LIFE HISTORY STUDIES OF HORSE NETTLE (SOLANUM CAROLINENSE) 1/

A. H. Furrer, Jr., and S. N. Fertig 2/

INTRODUCTION:

Horse nettle (Solanum carolinense), a dicotyledonous plant, is a member of the Solanaceae family, commonly referred to as the potato or nightshade family. It is a persistent perennial weed having a deeply penetrating, vigorous root system which permits storage of large food reserves. The plant is normally disseminated by means of seed, creeping roots, and root cuttings.

Economic losses caused by this weed are due to its vigorous competition to crop plants, as a possible source of poisoning to livestock, and as a host of several important plant diseases and insects. Its spiney character also presents a problem in hand harvested crops as well as in forage crops for livestock.

Thus far, effective and economic controls have not been developed. The purpose of this study was to investigate the reproduction and growth habit of the weed with the ultimate objective of finding a point in the life cycle where control methods might be more effective.

EXPERIMENTAL METHOD AND PROCEDURE:

The primary objectives of the field and greenhouse seed studies were to determine some of the factors influencing emergence from seed, the percentage emergence, and the extent of dissemination of the weed by means of seed.

Experiments were conducted concerning (a) emergence from seeds planted at several depths, (b) winter survival of seeds planted late in the growing season, (c) emergence of seedlings from Horse nettle infested soil, (d) emergence from seed scattered on the soil surface, (e) emergence of seedlings under natural field conditions, (f) emergence from seed planted in several different soil types, (g) emergence from Horse nettle berries, and (h) the numbers of seeds produced per berry.

Based on the results of this study, Horse nettle seedlings can emerge from seed planted four inches deep in well drained, friable soils.

Soil type greatly influences the extent of emergence from seed. Seedling emergence is highest in well drained, friable soils.

Horse nettle infestations were shown to originate from seed under field conditions. The extent of this source of infestation can be determined only by field observations over extensive areas. Nevertheless, control programs should include provisions for preventing seed formation and dissemination.

Seedlings were produced from whole and broken seed berries that were located

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1/ Work conducted as a part of the Cooperative Regional Project NE-42.

2/ Graduate student and Professor of Agronomy, respectively, New York State College of Agriculture, Cornell University, Ithaca, New York.

within three inches of the soil surface.

Mature seeds scattered on the soil surface in the fall, produced seedlings the following spring.

The average number of seeds per berry on mature plants in this study was 86 with a range of 11 to 189.

RESULTS AND DISCUSSION:

Seed Germination Tests

A number of Horse nettle seed emergence tests, carried out in the greenhouse and in the field, had indicated the high potential of the weed to spread by seed. To determine the factors influencing germination under more closely controlled conditions, tests were conducted at the Division of Seed Investigations, New York State Agricultural Experiment Station at Geneva. The tests included investigations of the influence on germination of temperature treatments, substrate moistening agents, weight of seed, and light.

Summary of Seed Germination Tests

In seed germination tests, the treatment of 20 to 30 degrees C. alternating temperatures (20 degrees C. for 15 hours, 30 degrees C. for 9 hours) using either tap water or 0.2 per cent solution of potassium nitrate as the substrate moistening agent, provided the most favorable conditions for germination. The highest germination obtained under these conditions was 70 per cent. Relatively good germination was also obtained using: (a) 10 to 30 degrees C. alternating temperatures, (b) 20 degrees C. constant temperature with potassium nitrate, and (c) 30 degrees C. constant temperature with potassium nitrate.

Light did not appear to be necessary for seed germination, but exposure of seed to light tends to increase the germination rate in the early stages of the germination period.

Heavier seed had a higher germination percentage than light seed.

Root, Stem, and Flower Studies

Horse nettle is readily propagated by means of the underground parts of the plant. Several experiments were conducted to determine the characteristics of these structures and the effects of certain cultural practices on reproduction from these parts. Studies were also made concerning flower and berry production by Horse nettle plants and the effects of cultural practices on their formation.

Investigations were made of: (a) the kinds of underground structures involved in reproduction, (b) vegetative reproduction from root cuttings obtained from various depths in the soil, (c) the influence of size of root cutting on reproduction, (d) the numbers of flowers and berries produced, (e) the growth characteristics of plants obtained from several locations in New York State, (f) the influence of depth of planting and length of drying of underground structures on reproduction, and (g) the effects of frequency of cutting on plant survival, rate of growth, seed production, and character of growth.

Summary of Root, Stem, and Flower Studies

No rhizome production was observed in any of the Horse nettle plants studied. New shoots, developing from the underground parts of the plant, appeared to start from adventitious buds produced at irregular intervals and at unpredictable locations along the roots.

Tap roots, growing at a depth down to 112 centimeters in the field, when excavated, cut into sections, and planted in soil, produced new shoots from adventitious buds.

Horse nettle was capable of reproducing vegetatively from very small root cuttings less than one inch long and 3/16ths of an inch in diameter.

Under greenhouse conditions in wooden flats, Horse nettle plants grown from root cuttings and seed the previous year, produced 9.3 and 10.1 new shoots, respectively. Established Horse nettle plants, grown from seed the previous year, produced an average of 2.5 new shoots per plant in outdoor 2 x 2 foot concrete frames having no artificial depth restrictions on root development. These observations suggest that Horse nettle plants grown in soils which restrict normal root development may produce a larger number of plants from buds than roots in soils permitting deep root penetration.

No significant differences were observed in the growth habit of plants grown in the greenhouse from root cuttings obtained from several different locations in New York State.

Root cuttings of Horse nettle plants produced new shoots when planted as deep as 18 inches in well drained, friable silt loam soil. Therefore, no appreciable reduction in Horse nettle production could be expected as a result of deep tillage operations.

Root cuttings exposed to drying on the soil surface for three days or longer, did not develop shoots when planted at two-inch depths in soil. Thus, Horse nettle roots lose their viability after being exposed to relatively short periods of drying on the soil surface.

Of 92 root cuttings planted at 1-1/2 to 2-inch depths, 91 (99 per cent) produced at least one plant and averaged 1.2 plants per cutting. This illustrates the high reproductive capacity of this plant from vegetative parts.

There was no mortality among Horse nettle plants grown from root cuttings that were clipped at a 2-1/2-inch height, at 5- to 8-day intervals throughout a single growing season. Seed production was almost entirely prevented.

Based on these results, the most appropriate time to clip Horse nettle plants to prevent the production of viable seed, is in mid-July and again in mid-August. It would be desirable to make further germination studies of seed harvested during the various stages of growth of plants grown from seed and from roots so that more reliable clipping schedules could be made.

The growth rate of Horse nettle plants was most rapid when they were maintained in a vegetative state by clipping.

The rate of top growth of Horse nettle plants grown from seed was slow when compared with the rate of root growth. This relationship insures firm establishment of the plant rather early in vegetative development. Therefore, chemical and cultural control programs may be more effective when directed at seedlings than at established plants.

SUMMARY:

Horse nettle seed acquired from a single source was capable of germinating and producing seedlings over a period of at least four months.

PRELIMINARY INVESTIGATIONS OF A GERMINATION AND GROWTH INHIBITOR PRODUCED BY YELLOW FOXTAIL (SETARIA GLAUCA (L.) BEAUV.)[1]

H. C. Yokum, M. W. Jutras, and R. A. Peters[2]

Many workers have shown that species of higher plants produce chemical substances which are toxic or inhibitory to other species. Bennett and Bonner (2) have shown that guayule excretes trans-cinnamic acid which is toxic to seedlings of the same species. LeTourneau and Heggeness (6) concluded that a germination and growth inhibitor in leafy spurge foliage is a basic nitrogen compound. Bonner (3) mentions that a toxic substance extracted from Encelia leaves was identified as 3-acetyl-6-methoxybenzaldehyde after recrystallization from ether. Barton and Solt (1) state that toxic substances generally belong to these groups: essential oils, alkaloids, glucosides, or ammonia from nitrogenous compounds.

As a part of the Regional NE-42 Cooperative Weed Control Project[3], this study was begun to determine the possible occurrence of a germination and growth inhibitor in Setaria glauca, a prevalent grassy weed. The experimental evidence indicated that foxtail produces a germination and growth inhibitor (s). Further studies were made to characterize the inhibitor.

METHODS AND RESULTS

The Effect of Foxtail Extraction on Germination and Root Growth

The yellow foxtail used in this study was either collected from the Agronomy Research Farm or grown in the greenhouse. The plants were dried in a forced air drier at 60-65°C for 24 hours and ground to pass a 40-mesh screen in a Wiley mill. Extractions of dry plants was accomplished by adding five grams of the ground material to 100 ml. of distilled water. This mixture was autoclaved for 10 minutes at 15 pounds pressure (260°F) and then filtered on a Buckner funnel. Four ml. aliquots of the filtrate were transferred to cotton stoppered test tubes and autoclaved for 10 minutes at 15 pounds pressure (260°F).

Germination Reduction and Root Growth Inhibition: Extracts of yellow foxtail were tested on seeds of five crops to determine possible germination inhibition. The seeds were surface sterilized by immersion in 95 percent methyl alcohol for 2-3 minutes, followed by 50-60 seconds in 1:1000 $HgCl_2$, and then rinsed several times in distilled water. Four ml. aliquots of the extraction were added to each

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[3] Weed Life Cycles, Soil Microorganisms and Light as Factors in the Control of Weeds in the Northeast.

dish containing ten seeds between two filter papers. Three replications of each seed were prepared. Control plates contained distilled water. The plates were then placed in a germinator at 25°C for four days. Due to the large number of germination tests to be conducted, it was necessary to determine which crop seed would be most sensitive to an inhibitor, consistent within replications, and quick to germinate. The effect of foxtail extractions on the germination of seeds of five crop plants is shown in Table 1.

Table 1. The Effect of Extracts of Yellow Foxtail on Germination of Various Seeds.

Test Seed	Germination in 4 days			Mean % Germination
	I	II	III	
Ladino Clover and Extract	10	40	20	23
Ladino Clover Control	90	100	90	93
Birdsfoot Trefoil and Extract	10	0	0	3
Birdsfoot Trefoil Control	10	0	20	10
Sweet Clover and Extract	0	30	0	10
Sweet Clover Control	90	95	90	92
Alfalfa and Extract	5	5	10	7
Alfalfa Control	100	100	100	100
Sudan and Extract	100	100	90	97
Sudan Control	100	100	100	100

Of the seeds tested, alfalfa proved most suitable. The hard seed conditions of birdsfoot trefoil makes it undesirable in a bioassay of germination. LeFevre and Clagett (4) got results in tests of sensitivity of various seeds similar to those shown in Table 1; again, alfalfa proved superior. In all cases where germination occurred the radicle was abnormally thickened and reduced in length. Measurement of radicle length was therefore also used as a criteria in bioassay of inhibitor concentrations. All subsequent bioassays were made with alfalfa seed.

Green vs. Dry Plant Material: LeTourneau and Heggeness (6) found that green material of spurge is somewhat more inhibitory than the dry material. To make a similar comparison with foxtail, aqueous extracts of green plant material were made by grinding in a Waring Blendor to a slurry and filtering. The slurry was not autoclaved. A comparison of the inhibitory effect of dry vs. green plant extractions gave the results shown in Table 2.

There was no significant difference between inhibitory effects of dry material and green material. Therefore, all subsequent extractions were made from dry plant material as this procedure was most convenient.

Tops vs. Roots: LeTourneau et al. (5) found different degrees of inhibition in various parts of plants. A comparison of yellow foxtail root extractions and top extractions gave the results shown in Table 3.

Table 2. Inhibition of Extracts from Green Material Compared with Dry Material.

Treatment	% Germination
Dry Plant Material Extraction	12
Green Plant Material Extraction	14
Control (Water)	100

Table 3. Inhibition of Extracts from Tops Compared with Roots.

Treatment	% Germination
Tops	15
Roots	15
Control (Water)	100

There were obviously no differences between roots and tops, therefore, both parts of the plants were used for subsequent extractions.

Characterization of Inhibitor

Heat: The effect of heat on the inhibitor (s) was checked. Autoclaving the foxtail extract for 20 minutes at 15 pounds pressure (260oF) did not affect the inhibitory activity of the extract (Table 4). Similar results were obtained by boiling the extracts.

Osmotic Pressure: A test of the possible effects of osmotic pressure was conducted. The osmotic pressure of foxtail, timothy, or orchard grass extractions was determined by the freezing point depression method (Table 5).

Table 4. The Effect of Heat on Inhibition.

Treatment	% Germination
Foxtail Extract (autoclaved)	0
Foxtail Extract (not autoclaved)	0
Control (Water	100

Table 5. The Effect of Osmotic Pressure on Inhibition.

Treatment	O.P.(Atms.)	% Germination
Foxatil Filtrate	2.95	5
Timothy Filtrate	2.97	70
Orchard Grass Filtrate	2.76	74
Sucrose Solution (0.11M)	2.95	95
Control (Water)	———	100

It is evident from the data that osmotic pressure is not a factor in inhibition by foxtail.

pH: A test of the possible effects of pH was also undertaken (Table 6). It is obvious that pH is not the imhibitory factor. These results with both osmotic pressure and pH agree with similar tests done with different plants by LeTourneau et al.(6).

Ashing: Five grams of the ground oven dried material were ashed in a crucible, and 100 ml. of distilled water added to maintain the concentration at the ratio of 5 grams: 100 ml. The pH after ashing was 11.4. A test showed this pH was completely inhibitory to germination. Thus, the pH was adjusted with ln HCl to neutrality and a gèrmination test as well as a comparison of radicle length was made (Table 7).

Table 6. The Effect of pH on the Inhibition of Germination.

Treatment	pH	% Germination
Foxtail Extract	5.6	15
Buffer Solution (KH_2PO_4)	5.6	100
Control (Water)	—	100

Table 7. Ashed vs. Dry Plant Material Extraction

Treatment	% Germ.	Radicle length (mm)
Ashed Foxtail	85	14
Foxtail Extract	0	—
Control (Water)	100	20

No appreciable amount of inhibition remained after ashing.

Dialysis: A water extraction of the plant material was dialysed in a colloidion membrane under running water (Table 8).

Table 8. The Effect of Dialysis on Inhibition

Treatment	% Germination	Radicle length (mm)
Dialysis - 46 hours	85	12
Dialysis - 105 hours	85	22
Control (Water)	90	24

The inhibitory fraction of the extraction was dialysed.

Soxhlet Extractions: Extractions with various organic solvents and water in a Soxhlet apparatus refluxed for 48 hours gave the results shown in Table 9. The organic solvent was volatilized by heating on a steam cabinet. Water was added to maintain volume. For each organic solvent, a solvent and distilled water mixture heated on the steam cabinet was tested as a control.

Table 9. Extraction of Inhibitor by Various Solvents

Solvent	% Germination	Radicle length (mm)
Water (H_2O)	0	___
Control (H_2O)	95	28
Ether	95	25
Control (H_2O + ether)	95	28
Chloroform	90	22
Control (H_2O + chloroform)	90	22
Acetone (50%)	90	22
Control (H_2O + acetone)	95	25
Benzene	80	28
Control (H_2O + benzene)	100	28
Methanol	20	9
Control (H_2O + methanol)	100	28

Extraction of the ground material with the various organic solvents has shown that the inhibitory fraction is soluble only in methanol.

Distillation of Basic Solution: To determine the presence or absence of ammonia in the water extract, a distillation was undertaken. One extract was made basic by the addition of NaOH to a pH 8, and then heated in a simple distilling apparatus to drive off any ammonia. These results are reported in Table 10.

Table 10. Distillation of Basic Solution.

Solvent	% Germination	Radicle length (mm)
Water extract	0	___
Basic Extract (distilled)	0	___
Control (H_2O)	100	28
Control (H_2O + NaOH) (pH adjusted to 8)	100	28

The inhibitor is not distilled from a basic solution.

Absorption on Exchange Resins: To determine if a charge exists on the inhibitor molecule, water extract was leached through columns of both amberlite cation exchange resin (IR-120) and amberlite anion exchange resin (IRA-400). The filtrate was tested for retention of inhibitory activity with the results given in Table 11.

Table 11. Germination and Root Growth Following Passage of Extractions through Exchange Resins

Treatment	% Germination	Radicle length (mm)
Anion Exchange Resin Filtrate	0	—
Cation Exchange Resin Filtrate	0	—
Both Resins	10	5
Water Extract	0	—
Control (Water)	90	—

There was no loss of inhibitory activity after leaching through the resin.

Absorption of Activated Charcoal: A test using 25 ml. of water extract and 2 grams of activated charcoal (Norit A, netural, decolorizing charcoal) was shaken together for 20 minutes on a wrist action mechanical shaker, and filtered on a Buckner funnel. A test of the activity of the filtrate gave the results in Table 12.

Table 12. The Effect of Activated Carbon on the Inhibitor

Treatment	% Germination	Radicle length (mm)
Norit - A	0	—
Water Extract	0	—
Control (Water)	100	28

The assay indicated that no absorption of the inhibitor by the activated carbon. occurred.

Chromatography: Paper partition chromatography techniques were used to further characterize the inhibitor (s). Methanol extractions of the foxtail were concentrated by heating and then decolorizing. The solvent was prepared from n-butyl alcohol, acetic acid, and water, 4-1-5 ratio, by volume. This mixture was separated in a separatory funnel and only the organic layer used as the solvent. The descending method of chromatography was employed.

A pencil line was drawn across a strip of Whatman's filter paper, three inches from the end. The paper was 20 x 7 inches. The concentrated methanol extraction was applied along the pencil line with a pipette drawn to a fine point. Five applications were made with a period of drying between each. The end of the paper nearest the pencil line was then inserted in a trough of the solvent. The whole was then suspended in a glass chamber. A petri dish of the solvent was placed in the bottom of the chamber to maintain a saturated atmosphere. When the solvent front had advanced a suitable distance along the paper strip, the paper was removed and dried in a hood.

The chromatograms were cut in 1.5 inch strips at right angles to the movement of the solvents. For assay, sections from each strip along with 10 alfalfa seeds and 1 ml. of water were placed in crucible lids and covered with watch glasses. The diameter of the crucible lid was 1.25 inches. Two controls were run with each assay, a water control and one from the chromatogram that only the solvent had covered. Table 13 indicates the data from the assays. The solvent front had moved 15.5 inches. The numbers each represent consecutive strips of 1.5 inches from the starting spot.

Table 13. Bioassay of Chromatogramed Extract

Chromatogram Section	% Germination	Radicle length (mm)
Check - water	90	17
Check - solvent	95	10
1	90	7
2	0	0
3	90	6
4	100	6
5	70	11
6	100	10
7	60	3
8	90	9
9	100	14
10	60	8

Areas 2 and 7 represent regions of strong inhibition with Rf values of 0.13 and 0.75. Areas 5 and 10 exhibited slight inhibition with Rf values of 0.40 and 0.90. A section of the chromatogram was developed for a general sugar test. The test consisted of:

a. Silver nitrate saturated water 0.1 vol.
   Acetone 20 vol.

b. Sodium hydroxide, 0.5% in ethanol

The chromatogram was first dipped through a, dried, dipped through solution b, and again dried. Area 2 showed a very strong sugar concentration, with area 7 exhibiting less concentration. Area 2 appeared to contain numerous sugars, whereas area 7 appeared to be a single sugar.

A section of the paper was developed with sulphanilic reagent, a test for phenols. No phenols were present in the areas of inhibition.

Discussion

Extracts of yellow foxtail plants, both green and dry, inhibited seed germination and growth of several crop species. The inhibitory activity of the tops and roots were not significantly different.

The inhibition appears to be due to factors other than pH or osmotic pressure.

The fact that the inhibitor is heat stable would indicate that it is not proteinaceous in character nor easily volatilized. Thus proteins and volatile compounds are eliminated.

Loss of inhibition by ashing would eliminate such possibilities as potassium or other mineral ions.

Since the molecule can be dialyzed a relatively small molecular weight is indicated.

Its insolubility in the organic solvents suggests a polar compound. Further, it is not easily ionized due to its free passage through medium-activity exchange resins.

Also eliminated is ammonia, as distillation of a basic extract does not cause loss of its inhibitory action.

Since the chloroform did not extract any inhibitor, the chloroform soluble group known as alkaloids is probably disqualified.

The activated carbon failed to remove the inhibitor, suggesting that pigments are not responsible for the inhibition.

Paper partition chromatography suggests that carbohydrates are involved in the inhibition.

The above results indicate that inhibition is probably due to sugar compounds.

Summary

Aqueous extracts of yellow foxtail were found to be inhibitory to the germination and growth of seeds of several crop plants. The germination and growth inhibitor produced by yellow foxtail was found to be present in equal amounts in both tops and roots of the foxtail plant. Further, no significant difference in inhibitory activity of dry vs. green plant material

was found to exist. An attempt to concentrate the inhibitor by various extractions and other means gave the following results:

	Treatment	Fate of Inhibitor
1.	Autoclaving (20 mins. @ 15 lbs. 260°F)	No loss of inhibition
2.	pH Test	No effect
3.	Osmotic Pressure Test	No effect
4.	Ashing	Loss of inhibition
5.	Dialysis	Dialyzable
6.	Soxhlet Water Extraction	Inhibitor soluble
7.	Methanol Extraction	Inhibitor soluble
8.	Exchange Resins, cation or anion	Not retained upon leaching
9.	Distillation of Basic Solution	Not distilled
10.	Activated Carbon Sorption	Not retained

It would appear that the inhibitor involved is a small, non-protein , non-volatile, polar molecule. The inhibitor also appears to be non-nitrogenous, non-alkaloid, and not easily ionized; the results with chromatograms indicates that Rf regions of strong inhibition are associated with high sugar concetrations.

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PROGRESS REPORT ON A STUDY OF THE GERMINATION AND GROWTH OF YELLOW FOXTAIL (SETARIA GLAUCA (L.) BEAUV.)[1]

Robert A. Peters and Harlan C. Yokum[2]

Introduction

Yellow foxtail is one of the most prevalent annual grasses in the Eastern United States. This species listed by Fernald[3] as *Setaria glauca* (L.) *Beauv.* is listed more commonly in older references as *Setaria lutescens*. An ubiquitous warm season grass, foxtail is most frequently associated with annual crops or with the first year of growth in perennial crops such as forages where the soil has been recently disturbed. While it has long presented a weed problem, relatively little is known as to the germination and growth characteristics of yellow foxtail. More specific information on the biological characteristics of this species is needed as a basis for an intelligent approach to both cultural and chemical control.

The foxtail investigation discussed in this paper was made at the Agronomy Research Farm of the University of Connecticut, Storrs, Connecticut. The following is a progress report of long term study of the growth characteristics of yellow foxtail being carried out as part of the Regional NE-42 Cooperative Weed Control Project[4].

Procedure

Seed for the germination study was collected in the field in the fall of 1958 and 1959 at the time that shattering normally occurs. Periodic attempts were made following harvest to induce germination thru altering the environment or thru treatment of the seed by chemical or non-chemical means. Germination was measured in triplicate for each treatment by placing 50 seeds per petri dish in a germinator at 80°F.

The germination experiments were carried out primarily in the laboratory. The progressive development of foxtail plants was followed both in the greenhouse and in the field from the time of germination until seed heads were produced.

The density of volunteer stands of yellow foxtail varies widely depending both on the abundance of seedlings and on the degree of control if attempted. Starting with a high density volunteer stand, periodic measurements

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[1] Contribution from the Storrs (Conn.) Agricultural Experiment Station, Storrs, Conn.
[2] Associate Agronomist and Research Assistant, respectively.
[3] Fernald, M. L. *Gray's Manual of Botany.* Eighth Edition. American Book Company, New York. 1950.
[4] Weed Life Cycles, Soil Microorganisms and Light as Factors in the Control of Weeds in the Northeast.

were made during 1958 both of naturally crowded plants and of plants widely spaced by hand weeding of adjacent plants.

Results

Germination Studies

Post-harvest Dormancy as Related to Time: No germination of newly harvested foxtail seed occurred following collection of 1958, 1959, or 1960 seed. Seed collected in 1954 stored under warm dry conditions still retained post-harvest dormancy in 1960 tests. After sufficient time lapse, most stored seed gradually lost dormancy. Five percent germination of the 1958 seed was obtained by December 1, 1958, and by mid-November for 1960 seed but not until the following February 1 for the 1959 seed.

Effect of Environment: Realizing that storage of seed in warm, dry conditions did not approximate the conditions to which seed is exposed in the field, an attempt to find an environment in which germination would be induced was made. Seed stored dry in a refrigerator for 10 weeks did not germinate. Alternate subjection of dry seed to freezing and room temperatures did not significantly increase germination. In a further test foxtail seeds were soaked in water for 12 hours. Germination of seed immediately following soaking was no greater than for non-soaked seed, namely 3 percent. The soaked seed was held in a refrigerator and samples removed daily for test. The germination gradually increased to 45 percent after 8 days, but decreased in the following four days being down to 25 percent on the last day of the experiment. Soaked seed held in a freezer and withdrawn daily for 12 days gave no germination. Seed soaked and then held at room temperature after drying displayed less lag in the onset of increased germination with 25 percent germination occurring after 4 days storage as compared to 8 percent germination from seed held in the cold. In summary, the treatment increasing germination the most was soaking the seed followed by storage for several days prior to placing in a germinator. Soaked seed stored in a freezer, however, failed to germinate upon removal.

Seed collected in the fall of 1959 was placed in seven environments with samples being withdrawn at 12 intervals from September 28, 1959 to February 26, 1960 for germination tests. All samples in a moist condition were in moist soil.

1. Constant cold - dry storage
2. Constant cold - wet
3. Constant warm (80°) - dry storage
4. Constant warm (80°) - wet soil
5. Constant warm (80°) but fluctuating dry and wet storage
6. Fluctuating warm and cold with wet storage condition (Seed placed in a screen and buried in the field.)

7. Fluctuating warm and cold with dry storage conditions. The seed was placed in a bottle which was alternated between the laboratory and outside.

There was only a slight increase in germination and this occurred only in the constant cold-moist or fluctuating warm-cold but moist storage. After seven weeks 10 percent germination was obtained with no increase in the following 12 weeks. The moist soil conditions and fluctuating temperature conditions to which the weeds stored in the field were exposed induced germination but the time when the seed first began germinating is not known. For a protracted period in the winter it was impossible to remove the seed from the frozen ground. When tested on May 27, a germination of 33 percent was obtained.

Seed pre-treated by soaking as well as non-soaked seed was held under each environment. No effect of this initial soaking could be found.

Influence of Scarification:

A. Scarification - By rubbing seed with sandpaper germination was increased to 30 percent. The non-scarified seed germinated 15 percent.

B. Scarification by immersion in fuming H_2SO_4 - Immersion in acid followed by thorough rinsing off of the acid was an effective scarification technique. Germination was 7 percent for non-treated seed, 51 percent for one-half hour immersion, and 40 percent for one hour immersion. Microscopic examination indicated numerous pits eroded thru the lemma and palea of the seed.

Influence of Chemical Treatment:

A. Immersion in indolacetic acid (IAA), thiourea dnd methyl alcohol. - The seed was scarified with sand paper prior to immersion for 5 and 24 hour intervals in solutions ranging from .05 to 50 ppm of IAA and from 25 to 50 ppm of thiourea. No signficant increase in germination was obtained. Some indication of reduction was obtained at 25 and 500 ppm thiourea at 24 hours. Seed immersed in methyl alcohol were injured with no germination occurring.

B. Immersion in nitrogen solutions -

1) Seeds scarified with sand paper immersed for 15.5 hours in 0.5, 1.0 and 2.0 percent KNO_3 germinated 80, 80 and 50 percent respectively. The non-treatment seed gave only 15 percent germination, thus the KNO_3 gave a very pronounced increase.

2) Seeds scarified with sandpaper immersed in 1 and 2 percent NH_4NO_3 solutions for 13 hours germinated 55 and 60 percent respectively as compared to 18 percent for the seed immersed in water only. When immersed in 1 percent KNO_3 for 76 hours, germination was 42 percent as compared to 19 percent for water soaked seed. In a similar experiment in which the seed was not scarified, seed in 1 and 2 percent NH_4NO_3 solutions gave 33 percent germination, in 1 percent KNO_3, 29 percent and untreated, 4 percent. Both nitrogen compounds gave a similar increase in germination.

3) Another nitrate compound , $MgNO_3$ at 2 percent, was compared with KNO_3 and NH_4NO_3 but was found relatively ineffective giving 10 percent germination as compared to the average of 33 percent for 2 percent NH_4NO_3.

C. Treatment with hydrogen peroxide - The possible effect of an oxidizing agent on germination was determined by exposing seed in flasks to 3.0, 0.3 and 0.03 percent hydrogen peroxide for 24 hours. Corresponding germination percentages were 5, 7 and 11 respectively as compared to 7 percent for non-treated seed. The slight increase at the high rate of H_2O_2 is probably not significant.

D. Treatment with EPTC - Seeds were soaked in 0.5, 5, 25, 50 and 500 ppm of EPTC solutions for 1, 7, 20 and 30 hour periods. A marked reduction in germination was obtained from 20 and 30 hours soaking in 50 and 500 ppm. There was evidence of an increased germination at 0.5 ppm EPTC for 1 hour with an average of 10 as compared to 3 percent for seed soaked in water only.

E. Effect of water temperatures - Seeds were immersed in water at 54, 68 and 78 and 92°C for 1 minute. Germination following this pre-treatment was 7, 2, 4 and 0 percent as compared to 13 percent in the check.

Foxtail Growth Patterns

The general development pattern of foxtail was traced in greenhouse grown plants. Under the conditions prevailing, tillers started to form about the sixth week of growth when the height of the initial stem or culm coming from the seed averaged nine inches. Tillers formed from adventitious buds on the lower nodes of the culm. Further tiller formation occurred with secondary tillers forming from the lower nodes of the primary tillers. Under field conditions tertiary tillers coming from the secondary tillers were also observed. Growth of the tillers was rapid with the height being comparable by the time of seed head emergence from the boot. Number of tillers in the greenhouse experiment were limited, averaging only 3 per plant. In the field, however, wide range in number of tillers was observed. Both plant density and age of plant influenced number of tillers formed. Close spacing resulted in an average of only 2 tillers per plant as compared to 56 on spaced plants.

The later germinating plants formed fewer tillers and did not grow as tall as earlier germinating plants, however, formation of the first tillers started only one week later. The earlier growing plants averaged only 9 inches as compared to 4.5 inches for later plants at the time tiller formation started. The onset of both of tillering and jointing tended to be independent of size of plant which suggested day length as a controlling factor.

In the eigth week of growth, short-day plants started to joing followed by heading. There was no indication of jointing or head formation on the long day plants even after eleven weeks when the experiment was terminated. Day length control of time of seed head formation was clearly shown in the greenhouse.

A close correlation was found between number of tillers and number of seed heads. To assess the seed producing potential of foxtail, seed counts of 7 heads selected at random were made. An average of 180 seeds per head were found. On uncrowded plants, with an average of 47 heads per plant in this experiment, over 8000 seeds per plant were found.

Discussion

Post-harvest dormancy in foxtail was quite marked. In Connecticut, foxtail seed shatters from the seed heads at least by mid-September. Several weeks of weather favorable for germination remains in the season. As a warm season annual, obviously foxtail would be ecologically adapted at high latitudes only if a post-harvest dormancy did exist.

A gradual change in the condition of seed under warm-dry conditions occurred. Seed collected in different years varied in the time interval required to induce germination. Even after passage of several months, however, germination of such seed averaged well below 25 percent.

Of the many treatments used, the treatment having the most pronounced effect on germination was scarification. Soaking the seed in fuming H_2SO_4 was considerably more effective than rubbing with sandpaper.

The pitting of the lemma and palea following scarification increased penetration of water. This was readily demonstrated by the movement of a Loeffler's methylene blue dye onto the embryo of the caryopsis while little or none can be detected in non-scarified seed. A close correlation was found between the percentage of seeds absorbing dye in particular seed lot and the germination percentage in the same seed lot. A close correlation between weight of water absorbed by seed and the observed rate of germination was noted for both 1955 and 1959 seed. The older seed having a germination of about 50 percent, increased in weight 19 percent after being imbibed, 1959 seeding giving no germination imbibed only 2.6 percent water by weight. It is suggested, therefore, that lack of water entry is an important factor in the dormancy of newly shattered yellow foxtail seed.

Any condition in the field which would tend to erode the lemma and palea would be expected to increase water uptake and thus germination. 1959 seed remaining in the soil over winter was germinating 33 percent by May 27. In general, temperature treatments of seed held in dry condition had little effect on germination. Seed first imbibed and then dried or seed held in moist, cold or moist fluctuating temperature conditions showed an increased germination.

Of the several chemical treatments used, only the nitrate compounds, KNO_3 and NH_4NO_3 increased germination markedly. Scarification prior to treatment nearly doubled the effect again suggesting that increased permeability of the liquid into the caryopsis was a factor.

Observation of the development of foxtail plants substantiates the marked ability of this annual species to reproduce itself. Plants slow to develop because of delayed germination associated with dormancy or tillage operations are still able to produce seed. When the required short day conditions prevail, seed heads will be formed even though plants may still be quite small.

The seed producing potential of yellow foxtail was strikingly shown by the production of very short seed heads from stubble 3 weeks following August 29 clipping of a stand in full bloom. Culms cut by tillage and partially buried may strike root and subsequently produce seed heads. Repeated clipping or tillage is required to completely stop seed formation by foxtail.

Summary

A study of the germination and growth characteristics of yellow foxtail (*Setaria glauca* (*L.*) *Beauv.*) has explained in part the well recognized persistence of this species.

A post-harvest dormancy assures that the seed will not germinate prior to the following spring when its life cycle can be completed. Of a large number of seed treatments aimed at inducing germination, scarification proved to be the most effective. Lack of water penetration to the embryo is at least one factor in the dormancy found in the first few weeks following harvest.

Field grown plants were found to be prolific seed producers. Many uncrowded plants produced over 8000 seed heads per plant. Day length, not plant size, was found to control the time of seed head production. This short day response ensures that plants will set seed before the growing season is terminated.

THE ANATOMICAL NATURE OF THE UNDERGROUND PORTIONS OF HORSENETTLE PLANTS

Thomas F. Tisdell[1], Richard D. Ilnicki[2] and William F. Meggitt[3]

ABSTRACT

The underground portions of horsenettle plants can be separated into three sections: the main or vertical tap root, the portion of the shoot extending from the main tap root to the soil surface, and lastly the lateral structure that connects adjacent shoots.

Inspection of a cross section from a main tap root revealed three distinct areas of tissue specialization. These include the epidermis, cortex, and vascular regions. The cortex was composed of three layers of elongated cells just beneath the epidermis, a group of undifferentiated, starch-containing parenchyma cells and a layer of cells known as the endodermis. Large xylem elements were observed in the center with smaller xylem elements radiating toward the edges. The xylem apparently matures in a normal centripetal fashion. Primary phloem was located between the primary and secondary xylem. Secondary xylem was developing from the pericycle toward the center of the root, and secondary phloem was being formed in an outward direction.

An examination of the lateral structure, shows an epidermis, a cortex of parenchyma cells, and a well defined endodermis. The central portion of this organ has approximately the same cellular characteristics as the main tap root. This section, however, contains more fiber cells than the main tap root.

The lateral structure and the main tap root conform quite closely with the characteristics of roots; therefore, it seems logical in future discussions to refer to the lateral as a creeping root rather than a rhizome.

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THE EFFECT OF HERBICIDES ON THE YIELD OF ESTABLISHED ALFALFA AND BIRDSFOOT TREFOIL

Stanford N. Fertig 1/
(A Summary Report)

INTRODUCTION:

The yield and quality of hay produced on New York farms is far below the desirable or easily obtainable level. This is the result of at least four factors: (1) the seeding mixtures used by many farmers is inferior to that which they should be using, (2) stands are left down much longer than desirable, (3) the time of cutting is much too late on most farms, resulting in reduced quality and total seasonal yields and (4) most legume stands have a serious infestation of broad-leaved weeds.

Changes in farming practices, based on presently available research information, could be put into use by farmers to materially improve the quality of present forage. For example, a wider use of grass silage would result in better quality roughage, more total tons of feed which animals would consume and at the same time reduce the weed problem on farms by eliminating a major source of re-infestation.

EXPERIMENTAL METHOD AND PROCEDURE:

A series of plots which were seeded to alfalfa and birdsfoot trefoil in the spring of 1957 were used for this study. The stand of both legumes was uniformily good on all plots. The varieties were Narragansett and Viking, respectively.

On April 25, 1959, when the alfalfa was 2 to 3 inches tall and the birdsfoot trefoil 1 to 2 inches tall, the chemicals listed in Table I were applied.

RESULTS AND DISCUSSION:

The initial injury to the alfalfa was more severe than to the birdsfoot trefoil. The early growth was reduced by all treatments and delayed blooming until the week of July 29. The yield of any cutting taken in June would have been very low; however, the recovery on the second cutting would have been more rapid and complete.

The early growth was reduced by all treatments with 2,4,5-TP at 1/2 pound and 4(2,4-DB) ester (ACP M-360) at 2 and 3 pounds being most severe. The injury to the legume stand was evidenced by stunting, reduced thickened leaflets and epinasty of the plant stems.

The recovery of the birdsfoot trefoil was more rapid than the alfalfa. However, some injury symptoms were evident on both crops at harvest (July 29) at the higher rates of each chemical and rate.

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The 2,4,5-TP was most effective in controlling the weed species present. At rates of 1/2 and 1.0 pound per acre, 2,4,5-TP effectively controlled: White Cockle (*Lychnis alba*), Grass-leaved Stitchwort (*Stellaria graminea*), Cinquefoil (*Potentilla recta*), Daisy Fleabane (*Erigeron canadensis*), Bull Thistle (*Cirsium lanceolatum*), and Ox-eye Daisy (*Chrysanthemum leucanthemum*). Poor control was obtained on Chicory (*Cichorium intybus*), Dandelion (*Taraxacum officinale*), Narrow-leaved Plantain (*Plantago lanceolata*) and Curled Dock (*Rumex crispus*).

The amine and ester formulations of 4(2,4-DB) resulted in poor control of the weed species present.

The average yield for each treatment on alfalfa and birdsfoot trefoil are shown in Table I.

Table I. The Effect of Spring Applied Herbicides on the Yield of Established Alfalfa and Birdsfoot Trefoil. 1959

Treatment No.	Chemical Used	Rate/A. Lbs. A.E.	Av. Yield in T/A. of Forage* First Cutting, 1959	
			Alfalfa	Birdsfoot Trefoil
1	4(2,4-DB) amine	1	1.33	1.05
2	4(2,4-DB) amine	2	1.47	1.14
3	4(2,4-DB) amine	3	1.26	1.02
4	4(2,4-DB) ester	1	1.39	1.20
5	4(2,4-DB) ester	2	1.41	1.20
6	4(2,4-DB) ester	3	1.28	1.05
7	2,4,5-TP ester	1/4	1.09	1.19
8	2,4,5-TP ester	1/2	0.99	1.17
9	2,4,5-TP ester	1	0.97	1.04
10	Check	0	1.37	0.97

*Average of 4 replicated plots.

SUMMARY:

Due to the initial injury and reduced growth of alfalfa and birdsfoot trefoil, spring treatments on established stands do not look promising. A preliminary summary of data from studies initiated in the spring of 1960 and other work in connection with weed control in birdsfoot trefoil seed production areas show similar results to those reported in this paper.

Note: A mimeographed copy of complete paper is available from the author.

THE EFFECTIVENESS OF PRE-EMERGENCE APPLICATIONS OF HERBICIDES FOR WEED CONTROL IN OATS AND THE ESTABLISHMENT OF FORAGE SEEDINGS

Stanford N. Fertig 1/

(A Summary Report)

INTRODUCTION:

Since the introduction of selective herbicides in 1945, hundreds of compounds have been screened and field tested for weed control in small grains and the associated forage seedings.

A wide range of weed species can be effectively controlled by compounds such as 2,4-D, MCP, 2,4,5-TP and 4(2,4-DB) when applied as post-emergence sprays. However, the important legume species are in a susceptibility grouping less resistant than many of the common weed species. The degree of injury to the legume stand is a variable factor influenced by time of treatment, the nature of the canopy to protect it, climatic conditions, the volume of water used in application, the degree of competition offered by the small grain and the interval of this competition.

This study was initiated to investigate the effectiveness of herbicides applied pre-emergence to the oats and the legume species for controlling the common weed species prevalent in oats and to determine the susceptibility of alfalfa to the kind and rate of chemicals used.

EXPERIMENTAL METHOD AND PROCEDURE:

On May 14, 1958 certified Rodney oats were planted in a randomized plot design with 5 replications of each treatment. All plots were then seeded to DuPuits alfalfa at 10 pounds per acre using a Brillion cultipacker seeder. To establish a uniform stand of broad-leaved weeds, all plots were over-seeded with 10 pounds of mustard (*Brassica kaber*) per acre using a wheel-barrow seeder.

On May 21, the chemicals listed in Table I were applied as pre-emergence sprays. All treatments were applied in 30 gallons of water per acre.

The chemicals, rates used, yield of oats for 1958 and the forage yields for 1959 are reported in Table I.

RESULTS AND DISCUSSION:

The emergence of oats was normal on all plots except those treated with Fenuron and the 3 and 4 pound rates of Eptam. At all rates of Fenuron, the emergence of oats was slower and the plants showed a chloratic condition at emergence. The entire stand of oats on these plots was dead within 3 weeks after emergence.

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Table I. Effect of Pre-emergence Treatments on Oats and Forage Legume Yields

Treatment No.	Chemical	Rate/A. lbs. A.E.	Yield of Oats Bu/A. 15% Moisture 1958	Yield of Forage Tons/A. at 15% Moisture 1st Cut. 1959	Yield of Forage Tons/A. at 15% Moisture 2nd Cut. 1959	Total Forage Yield - 2 cuts Tons/A. 1959
1	Sinox P.E.	2.0	80.8	1.87	1.65	3.52
2	Sinox P.E.	4.0	77.1	1.41	1.43	2.84
3	4(2,4-DB) Amine	1.5	80.1	1.66	1.60	3.26
4	4(2,4-DB) Amine	3.0	75.1	1.91	1.55	3.46
5	ACP M-119	2.0	71.0	1.23	1.17	2.40
6	ACP M-119	4.0	71.0	0.95	1.78	1.73
7	Eptam	1.5	74.9	1.72	1.46	3.18
8	Eptam	3.0	67.0	2.18	1.86	4.04
9	Eptam	4.0	68.6	2.07	1.67	3.74
10	MCP Amine (Dow)	0.5	76.3	1.18	1.09	2.27
11	MCP Amine (Dow)	1.0	76.6	0.76	0.57	1.33
12	2,4,5-TP (AmChem)	0.75	80.7	0.69	0.47	1.13
13	2,4,5-TP (AmChem)	1.5	77.2	0.40	0.33	0.73
14	ACP L-688	0.75	83.4	1.33	1.35	2.68
15	ACP L-688	1.5	71.1	0.76	0.56	1.32
16	ACP L-685	0.75	77.3	1.01	0.85	1.86
17	ACP L-685	1.5	80.5	0.85	0.61	1.46
18	Fenuron	2.0	00.0	0.46	0.29	0.75
19	Fenuron	4.0	00.0	0.31	0.48	0.79
20	Fenuron	6.0	00.0	0.36	0.51	0.87
21	Neburon	1.5	79.2	1.93	1.81	3.74
22	Neburon	3.0	81.2	1.96	1.74	3.70
23	Neburon	6.0	75.2	1.87	1.53	3.40
24	Check	0.0	73.2	1.79	1.55	3.34

The most effective chemicals in reducing the weed population were Neburon and Eptam. These were followed by 2,4-D amine, Sinox P.E., ACP L-685, ACP L-688, MCP amine, 4(2,4-DB) and ACP L-119.

Except for the Fenuron and 2,4-D plots, there was no evidence of any effect on the emergence and establishment of the alfalfa seeding.

The best stands of seedling alfalfa were obtained on the Neburon, Eptam and Sinox P.E. plots, with Neburon being exceptional. Throughout the growing season, there was no weed growth, oats or legume development on the Fenuron plots.

Observations during the growing season did not show any injury to the oats, panicle development or maturity. The yield of oats and their test weight were affected.

SUMMARY:

Pre-emergence treatments show promise for the control of early germinating weeds in oats and the associated legume seeding. The only species not controlled was ragweed (Ambrosia artemisiifolia), and the perennials such as: Ground Cherry (Physalis subglabrata), Flower-of-the-Hour (Hibiscus trionum) Horse Nettle (Solanum carolinense), and quackgrass (Agropyron repens).

Effective weed control and legume injury may be variable with 2,4-D and related compounds due to rainfall, soil type and temperature. Neburon, Eptam and the Dinitro amines should be further investigated.

Note: A mimeographed copy of complete paper is available from author.

THE EFFECT OF WEED COMPETITION AND THE TIME OF CHEMICAL TREATMENT ON OAT YIELDS AND THE EFFECT ON LEGUME STAND AND YIELD

Stanford N. Fertig 1/

(A Summary Report)

INTRODUCTION:

A valuable aid in helping to sell a weed control program to farmers is to have available, accurate research evidence on the losses due to weed competition and the returns which can be expected from recommended practices. Significant questions include: the effect of various weed population densities on crop yields, when the competition occurs and in the case of small grains used as a companion crop with legume seedings, the effect on legume establishment and subsequent yields. Accurate data of this nature is necessary to determine the level of costs farmers can economically afford to invest in mechanical and chemical control methods.

EXPERIMENTAL METHOD AND PROCEDURE:

In the spring of 1957 and 1958, field experiments were initiated to investigate the effect of weed competition on oats, the effect of removing the competition at various growth stages of the oats by the use of herbicides or hand-weeding and to study the resulting effects of weed competition on legume stand establishment and yield of forage.

The experimental design was a randomized block with 5 replications of each chemical or cultural treatment.

The plots were seeded to oats at 1-1/2 bushels per acre in early May. Immediately after drilling the oats, the entire plot area was seeded to DuPuits alfalfa at 10 pounds per acre and 4 of the 5 blocks were broadcast seeded with 10 pounds of wild mustard (*Brassica kaber*), using a wheel-barrow type seeder.

The treatment schedule included plots seeded to mustard at 10 pounds per acre and treated with Dinitro amine, 2,4-D amine and MCP amine at weekly intervals from emergence of the oats to 7 weeks after emergence. These chemically weeded plots were compared to plots seeded to mustard and hand-weeded at weekly intervals plus those not seeded to mustard, but also hand-weeded. Plots seeded to mustard and not weeded, plus plots not seeded to mustard and not weeded were included in each block for comparison.

Due to rainy weather and the time required for the hand-weeding operation, the weekly schedule was not exactly maintained. However, in only two instances was the spraying or hand-weeding schedule delayed longer than the 7-day interval.

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Table I. Yield of Oats, Test Weight and Forage Yields From Competition Study, 1958.

Treatment Interval in Weeks after Emergence of Oats	Nature of Competition	Chemical or Cultural Treatment	Rate/A. lbs. A.E.	1958 Average yield of oats at 15% moisture. Bu./A.	1958 Test weight of oats lbs./Bu.	1959 Total yield of forage (2 harvests) Tons/A. 15%
1	Seeded to mustard	Sinox P.E.	1-1/8	76.7	33.3	3.10
	Seeded to mustard	2,4-D amine	1/4	79.4	32.7	3.29
	Seeded to mustard	MCP amine	1/4	76.3	33.3	3.19
	Seeded to mustard	Hand-weeded	None	77.1	33.5	3.42
	Seeded to mustard	Check	None	80.7	33.7	3.32
	Not seeded	Hand-weeded	None	79.5	32.3	3.66
2	Seeded to mustard	Sinox P.E.	1-1/8	68.8	33.6	3.24
	Seeded to mustard	2,4-D amine	1/4	79.8	34.2	3.30
	Seeded to mustard	MCP amine	1/4	76.6	34.2	3.20
	Seeded to mustard	Hand-weeded	None	76.1	33.8	3.30
	Seeded to mustard	Check	None	79.9	33.4	3.36
	Not seeded	Hand-weeded	None	76.5	33.2	3.42
3	Seeded to mustard	Sinox P.E.	1-1/8	70.0	33.9	3.44
	Seeded to mustard	2,4-D amine	1/4	78.0	34.2	3.30
	Seeded to mustard	MCP amine	1/4	71.3	33.9	3.20
	Seeded to mustard	Hand-weeded	None	71.5	33.6	3.42
	Seeded to mustard	Check	None	74.3	33.4	3.31
	Not seeded	Hand-weeded	None	76.5	33.0	3.25
4	Seeded to mustard	Sinox P.E.	1-1/8	67.9	35.0	3.58
	Seeded to mustard	2,4-D amine	1/4	74.1	35.3	2.98
	Seeded to mustard	MCP Amine	1/4	71.8	34.3	2.97
	Seeded to mustard	Hand-weeded	None	72.1	33.8	3.13
	Seeded to mustard	Check	None	74.5	33.5	3.23
	Not seeded	Hand-weeded	None	72.7	33.0	2.91
5	Seeded to mustard	Sinox P.E.	1-1/8	62.4	34.0	3.57
	Seeded to mustard	2,4-D amine	1/4	71.5	33.7	3.39
	Seeded to mustard	MCP amine	1/4	72.8	33.8	3.39
	Seeded to mustard	Hand-weeded	None	72.1	33.7	3.43
	Seeded to mustard	Check	None	80.4	33.2	3.21
	Not seeded	Hand-weeded	None	75.3	33.7	3.30

Table I (cont'd)

Treatment Interval in Weeks after Emergence of Oats	Nature of Competition	Chemical or Cultural Treatment	Rate/A. lbs. A.E.	1958 Average yield of oats at 15% moisture. Bu./A.	1958 Test weight of oats lbs./Bu.	1959 Total yield of forage (2 harvests) Tons/A. 15%
6	Seeded to mustard	Sinox P.E.	1-1/8	83.5	34.3	3.36
	Seeded to mustard	2,4-D amine	1/4	79.9	33.3	3.52
	Seeded to mustard	MCP amine	1/4	78.2	33.7	3.45
	Seeded to mustard	Hand-weeded	None	76.7	34.4	3.12
	Seeded to mustard	Check	None	79.9	33.4	3.32
	Not seeded	Hand-weeded	None	77.0	33.4	3.28
7	Seeded to mustard	Sinox P.E.	1-1/8	70.7	34.1	3.35
	Seeded to mustard	2,4-D amine	1/4	79.4	33.9	3.64
	Seeded to mustard	MCP amine	1/4	74.0	33.7	3.44
	Seeded to mustard	Hand-weeded	None	72.4	34.9	3.35
	Seeded to mustard	Check	None	74.3	33.4	3.31
	Not seeded	Hand-weeded	None	71.1	33.7	3.07

RESULTS AND DISCUSSION:

The results of the 1957 and 1958 experiments showed the same general trends. The 1958 data will be used to illustrate the results obtained.

The yield per acre and test weight of oats for the 1958 season and the forage yields (total for 2 harvests) for 1959 are shown in Table I.

A comparison of the yield data for oats and for forage illustrates one of the problems in obtaining accurate and reliable effects of weed competition on crop growth under field conditions. With the favorable growing season and ample moisture for crop growth during 1957 and 1958, the yield differences are not significant. Also, with the excellent early canopy afforded by the rapidly developing mustard plants, the legume stand was not injured by the herbicides used. Actually, the disturbance to the soil and to the seedling legumes by hand-weeding was as severe as the effect of weed competition. The yield of oats and forage on the check plots averaged just as high as the chemically weeded or hand-weeded plots.

Other factors of significance in this type of study include: (1) the new varieties of forage legumes having more rapid seedling establishment, vigor and growth which allow them to better compete for light, (2) generally higher fertility levels where nutrients are more generally sufficient for establishment and (3) changes in seeding and management practices which favor the crop being planted.

Note: A mimeographed copy of the complete paper is available from the author.

THE USE OF FENAC FOR QUACKGRASS (AGROPYRON REPENS) CONTROL IN CORN: PLOW, FIT, PLANT AND TREAT.

Stanford N. Fertig 1/

(A Summary Report)

INTRODUCTION:

An increasingly serious weed problem on New York farms is annual and perennial grasses. With the use of selective herbicides to control broad-leaved species and the reduced use of cultural practices, the grass problem has gradually increased and is presently the most competitive problem on many farms. This is particularly true of quackgrass (*Agropyron repens*).

Several new chemicals have shown promise for quackgrass control in corn. Some of these compounds show promise for seasonal control, while others actually eliminate or markedly reduce the stand of quackgrass.

EXPERIMENTAL METHOD AND PROCEDURE:

The objective of this particular study was to investigate the effectiveness of Fenac (ACP M-673-A) for quackgrass control in corn when applied at low rates as pre- or early post-emergence treatments.

The experimental design was a randomized block with four replications of each treatment.

The experimental area was plowed, fitted and planted to corn on May 20, 1959. The Fenac at rates of 2,3,4 and 6 pounds actual per acre were applied at four dates after planting as follows

A. Immediately after planting
B. 3 days after planting
C. 6 days after planting
D 9 days after planting

The plots were not cultivated during the growing season.

RESULTS AND DISCUSSION:

The dates of application and the rates of chemical used (Table 1) showed no retarding effect on corn emergence or on plant population. However, the development of the corn plants was affected by the 6-pound rate applied immediately after planting and by the 4- and 6-pound rates applied 9 days after planting. The treatments applied 9 days after planting were post-emergence to the corn. At these higher rates, the diameter of the stalk and the leaf area were visibly reduced. Based on measurements during the growing season, the height of the corn was not affected by any of the rates of chemical used.

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Table 1. Yield of Silage Corn and Quackgrass Stand Counts, 1959.

Interval of treatment after planting	Chemical used	Rate/A. lbs. A.E.	Average yield/A. Tons of silage 75% moisture	Shoot Counts of quackgrass October, 1959
Immediately	Fenac	2	19.39	680
		3	20.33	434
		4	20.12	374
		6	16.77	402
	Check	0	17.97	481
3 days	Fenac	2	21.18	404
		3	19.43	368
		4	18.65	414
		6	19.99	289
	Check	0	18.04	374
6 days	Fenac	2	21.29	487
		3	20.74	468
		4	19.14	503
		6	21.58	367
	Check	0	19.05	367
9 days	Fenac	2	18.13	534
		3	17.89	550
		4	15.15	619
		6	15.99	447
	Check	0	15.69	535

The chemical treatments were particularly effective in reducing the broad-leaved and annual grass problem. The stand counts (3 - 2 sq. ft. quadrats) per plot showed effective control of the following species at all rates used.

Wild Mustard (*Brassica kaber*)
Lamb's-quarters (*Chenopodium album*)
"Red root" Pigweed (*Amaranthus retroflexus*)
Yellow Foxtail (*Setaria leutescens*)
Yellow Rocket (*Barbarea vulgaris*)
Wild Carrot (*Daucus carota*)
Smartwood (*Polygonum pennsylvanicum*)

The effect of the treatments on the yield of silage corn and their effectiveness in reducing the number of shoots of quackgrass are shown in Table 1. The stand counts which were made in mid-October do not reflect the differences observed during the growing season. They do reflect the actual control of quackgrass on the plots.

Fenac at 3 pounds per acre and above prevented the development of quackgrass for the growing season. It was far more effective than 2,4-D for broad-leaved and annual grass control.

SUMMARY:

Based on a number of experiments using Fenac, the compound shows real promise for weed control. However, residue problems in relation to the growing crop and residual effect of the chemical in the soil raises the question of any wide usage of this compound for broad-leaved weed and grass control in field crop rotations.

Note: A mimeographed copy of the complete paper is available from the author.

THE EFFECTIVENESS OF FALL AND SPRING HERBICIDE TREATMENTS FOR QUACKGRASS CONTROL IN CORN, 1960

Stanford N. Fertig 1/

(A Summary Report)

INTRODUCTION:

In view of the diversity of management practices followed by farmers, the methods of Quackgrass control and the timing of applications must also be different. With the chemicals presently available, fall applications would have some definite advantages as regards plowing, planting and possible residue, which, without proper timing, could result in crop injury.

EXPERIMENTAL METHOD AND PROCEDURE:

In the fall of 1959 and the spring of 1960, the herbicides in Table I were applied as foiliage sprays. The fall treatments were applied on October 8, 1959, and the spring treatments on April 23, 1960.

The fall treatments were applied on sod ground and plowed 30 days later. The spring treatments were applied on sod ground for the spring plowed half of the plot but was over-plowed ground on the fall plowed half of the plot.

The spring treated plots were plowed 6 days after treatment. The cultural operations before planting were the same for all plots and all plots were planted to corn, using the same variety and fertilizer rate on June 4, 1960.

The corn on a portion of each plot (fall and spring plowed) was cultivated two times during the growing season.

During the growing season, visual observations and stand counts on Quackgrass were made on all plots. On September 8, 1960, silage yields were taken on all plots.

RESULTS AND DISCUSSION:

The most promising treatments for Quackgrass control were those including Atrazine, Simazine or Propazine as a spring treatment. The other combinations of treatments shown in Table I did not effectively control Quackgrass for the growing season or did not reduce the Quackgrass stand as determined by visual observations. In each instance the comparison was made with a check treatment.

The most promising control of Quackgrass was on the spring plowed plots. However, the broad-leaved weed and annual grass control was best on fall plowed plots. With the spring application going on plowed ground on these plots, better control was obtained on the annual broad-leaved weeds and annual grasses.

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Table 1. Chemicals and Rates Used as Fall and Spring Treatments on Quackgrass, 1960.

Treatment No.	Chemical Used Fall	Rate/A. lbs. A.E.	Chemical Used Spring	Rate/A. lbs. A.E.
1	Atrazine	2.0	Atrazine	2.0
2	Atrazine	3.0	Atrazine	3.0
3	Simazine	2.0	Simazine	2.0
4	Simazine	3.0	Simazine	3.0
5	Dalapon	4.0	Dalapon	4.0
6	Dalapon	5.0	Dalapon	5.0
7	Atrazine	2.0	Amitrol-T	4.0
8	Propazine	2.0	Propazine	2.0
9	Propazine	3.0	Propazine	3.0
10	Fenac	3.0	Fenac	3.0
11	Fenac	4.0	Fenac	4.0
12	Dalapon	5.0	Simazine	3.0
13	Dalapon	5.0	Atrazine	3.0
14	Dalapon	5.0	Propazine	3.0
15	Fenac	4.0	Atrazine	3.0
16	Check	0	Check	0

Table 2. Stand Counts of Quackgrass and Yields of Silage Corn from Fall and Spring Treatments, 1960.

Treatment No.	Average No. of Quackgrass shoots/sq. ft.*				Yield of Silage Corn in Tons/A. at 75% Moisture**			
	Fall		Spring		Fall Plowed		Spring Plowed	
	Cultivated***	Not Cultivated	Cultivated	Not Cultivated	Cultivated	Not Cultivated	Cultivated	Not Cultivated
1	4.5	9.5	1.0	1.6	14.8	16.2	19.6	14.9
2	0.17	1.7	0.14	0.33	16.0	15.8	18.0	14.4
3					13.7	12.2	18.0	13.9
4	9.5	9.5	3.3	4.9	17.5	13.0	17.1	13.5
5					12.1	6.3	18.7	12.8
6					12.6	10.8	17.5	11.5
7					14.0	10.3	15.5	14.0
8	6.3	8.5	3.2	5.7	16.0	15.5	16.7	14.0
9	1.3	4.0	0.7	0.5	18.9	13.1	18.0	16.7
10					14.6	10.8	19.8	13.3
11					14.0	13.3	17.8	14.4
12					16.0	12.1	18.2	10.8
13	9.7	17.0	6.0	6.0	15.3	14.9	20.0	16.9
14	11.3	18.0	6.0	7.5	16.6	18.2	18.5	16.0
15	11.0	15.0	5.0	6.7	15.5	14.8	16.6	13.7
16	26.0	25.0	25.0	23.0	12.1	11.5	14.6	12.1

* The average of 3 - 2 sq. ft. quadrat counts per plot. The blank spaces in the table were those plots where the stand of Quackgrass, based on visual observation, compared to the check treatment.

** The yield values have been corrected for stand -- to the same number of harvested plants per plot.

*** The stand count on the cultivated check plots was made in the row.

On spring plowed plots, where the fall and spring applied chemical was plowed down, the control of annual species was poor.

Although not significant, the spring plowed plots yielded somewhat higher than the fall plowed plots, except treatments 8, 14 and 15. On each of these plots, Quackgrass control was good.

In three treatments (2, 3 and 14), fall plowed and not cultivated yielded higher than cultivated. In only two treatments (4 and 9) did fall plowed and cultivated outyield spring plowed and cultivated. In six treatments out of 15, the fall plowed and not cultivated plots yielded higher than the spring plowed not cultivated. Again, Quackgrass control was good on these treatments, resulting in less competition to the corn.

Also, the yield differences are greater between cultivated and not cultivated on the spring plowed plots than on the fall plowed. This is the result of increased competition due to annual borad-leaved weeds and annual grasses. Cultivation was most beneficial on those plots where poor chemical control was obtained.

SUMMARY:

Based on stand counts and yields of silage, the control of Quackgrass on spring plowed plots was superior to fall plowed. Thus, in the combination of fall and spring treatments, the fall plowing will result in better annual broad-leaved weed and annual grass control but the spring plowing will result in better Quackgrass control.

Note: A mimeographed copy of the complete paper is available from the author.

THE CONTROL OF BEDSTRAW (GALIUM MOLLUGO) IN ESTABLISHED STANDS OF BIRDSFOOT TREFOIL USING 2,4,5-TP

Stanford N. Fertig [1]

(A Summary Report)

INTRODUCTION:

Ladies Bedstraw (*Galium mollugo*) has spread rapidly in New York in the past 10 years. It is one of the most common weeds of roadsides and has become a menacing problem in permanent pastures, established stands of birdsfoot trefoil and in lawns.

The rapid spread of bedstraw can be attributed in a large part to the use of European sources of birdsfoot trefoil seed and in more recent years to the purchase of poorly cleaned local seed supplies.

EXPERIMENTAL METHOD AND PROCEDURE:

In the spring and summer of 1959, four separate areas of birdsfoot trefoil, uniformly infested with bedstraw, were treated with two formulations of 2,4,5-TP.

The chemicals used, rates per acre and dates of treatment are shown in Table 1. The March, April and May treatments were on first growth bedstraw and birdsfoot trefoil. The August treatments were on regrowth after first cutting. The regrowth on the bedstraw was 3 to 4 inches tall when the August treatments were applied.

RESULTS AND DISCUSSION:

The control of bedstraw was excellent on the first three dates of treatment as shown by the stand counts made August 19, 1959, Table 1. The growth of bedstraw at time of treatment ranged from barely visible shoot emergence from the crowns on March 24 to plants 12 to 18 inches tall on May 12.

Due to the very poor stands of birdsfoot trefoil on the plots, accurate evaluation of injury was not possible. However, the treatments applied on March 24 and April 18 did not severely injure the plants present. Compared to the check, there was no reduction in birdsfoot trefoil stand.

The treatments applied August 19 on the regrowth after first cutting were not effective in controlling bedstraw at any of the rates of chemical used. Observations made on October 28, 1959 and the stand counts made April 21, 1960 showed recovery on all plots.

The treatments applied on March 24, April 18 and May 12 gave excellent

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Table 1. Treatments Used and Stand Counts on Bedstraw in Birdsfoot Trefoil.

Treatment No.	Chemical Used	Rate/A. lbs. A.E.	Average number of bedstraw shoots per sq. ft.*-Aug.,1959 Dates of treatment 3/24/59	4/18/59	5/12/59	Average number of bedstraw plants** per plot (6 x 30 ft.) Apr. 21, 1960 Dates of treatment 3/24/59	4/18/59	5/12/59	8/14/59
1	2,4,5-TP (AmChem)	1	0	0	0	7.5	3.0	0.75	95
2	2,4,5-TP "	2	0	0	0	12.0	4.8	0.50	61
3	2,4,5-TP "	3	0	0	0	3.7	2.2	0.50	39
4	2,4,5-TP (Dow)	1	0	0	0	5.0	3.0	0.75	110
5	2,4,5-TP "	2	0	0	0	8.2	2.8	0.25	63
6	2,4,5-TP "	3	0	0	0	5.0	1.8	0.25	27
7	Check	0	37	35	34	148	122	116	145

* The average of 3 - 2 sq. ft. quadrat counts per plot. The values are individual stems of bedstraw,

** The average total number of bedstraw clumps per plot. The average of 4 replications.

control of additional weed species as follows:

Philadelphia Fleabane (Erigeron canadensis)
Rough Cinquefoil (Potentilla recta)
Ox-eye Daisy (Chrysanthemum leucanthemum)
Goldenrod (Solidago spp.)

The following weed species were not controlled by 2,4,5-TP:

Dandelion (Taraxacum officinale)
Canada Thistle (Cirsium arvense)
Chicory (Cichorium intybus)

The stand counts made April 21, 1960 show the re-infestation from seed. These were seedling plants having a single shoot. The re-infestation was least from the treatments applied May 12, 1959.

SUMMARY:

2,4,5-TP at rates of 1 pound per acre effectively controlled bedstraw. Bedstraw is susceptible over the period April to June. Empire birdsfoot is less susceptible to injury than Viking, based on other experiments.

2,4,5-TP is not cleared for use on forage to be grazed by or fed to milking cows or beef animals intended for slaughter.

Note: A mimeographed copy of the complete paper is available from the author.

PRELIMINARY RESULTS ON THE CONTROL OF CYPRESS SPURGE (EUPHORBIA CYPARISSIAS)

Stanford N. Fertig 1/

(A Summary Report)

INTRODUCTION:

Cypress Spurge (*Euphorbia cyparissias*) was introduced into the United States as an ornamental and has been widely used for this purpose. Over the years it has been extensively planted in cemeteries and thus become known as Graveyard Weed.

Small infestations of Cypress Spurge have been reported from several locations in New York. The largest known infestations are in Orange, Herkimer, Oneida and Broome Counties. Smaller infestations are scattered throughout western New York State.

Cypress Spurge is a poisonous plant. Cases of dermatitis in persons handling the plant are very common. Animals will eat hay containing dry plants of spurge but usually will not eat growing plants. This factor contributes to uninhibited spread of the plant in permanent pastures, along roadsides and in waste areas where plowing is infrequent.

EXPERIMENTAL METHOD AND PROCEDURE:

On September 13, 1958, the chemicals listed in Table I were applied to mature stands of Cypress Spurge. The experimental design was a randomized plot with 2 replications of each treatment. All treatments were applied in 30 gallons of water per acre. The weather was sunny, calm, with a temperature of 75 degrees.

RESULTS AND DISCUSSION:

The effectiveness of the chemical treatments in reducing the stand of Cypress Spurge are shown by the stand counts (Table I) made on August 19, 1959. Only two compounds showed promise: an emulsifiable acid of 2,4-D (ACP-638 and Amino Triazole (powder)). As shown in the table, the average number of shoots were about one-half that found on the check plot and less than one-half the number for some of the other chemical treatments. The stand counts for the Simazine and 2,3,6-trichlorobenzoic acid (Benzac 1281) plots would indicate an increase in the number of shoots. A similar response was observed with plots of Leafy Spurge (*Euphorbia esula*) established in 1958 and 1959.

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Table I. Chemicals Used and Stand Counts on Cypress Spurge (Euphorbia cyparissias). 1958.

Treatment No.	Chemical	Rate/A. Lbs. A.E.	August 18, 1959 Average No. of Shoots/Sq. ft. Average of 3 - 2 sq. ft. quadrats
1	ACP - 638	6	8.8
2	ACP - 638	12	7.6
3	ACP - 638	6	7.3
4	Simazine	10	18.5
5	Simazine	20	12.3
6	Simazine	10	18.5
7	Amino Triazole(P)	5	9.4
8	Amino Triazole(P)	10	9.1
9	Amino Triazole(P)	5	7.6
10	Benzac 1281	6	17.8
11	Benzac 1281	12	27.0
12	Benzac 1281	6	22.8
13	Check	0	16.7

On August 18, 1959 a number of the above plots were re-treated as shown in Table II. The Cypress Spurge was 8 - 10 inches tall when treated and all chemicals were applied in 30 gallons of water per acre.

Table II. Re-treatments on Cypress Spurge (Euphorbia cyparissias) August 18, 1959

Treatment No. 1959	Treatment No. 1958	Chemical Used in 1959	Rate/A. lbs. A.E.	Av. No. Shoots/sq. ft. at time of treatment
1	13	Atrazine	4	
2	12	Atrazine	8	22.8
3	4	Amitrol-T	4	
4	5	Amitrol-T	8	
5	8	Karmex-Diuron	7.3	
6	9	Amino Triazole (P)	5	
7	3	ACP - 638	6	

Visual observations and ratings on these plots during 1960 showed Amitrol-T Amino Triazole (P), ACP-638 to be most effective in reducing the stand of Cypress Spurge.

Observations on other plots established in August 1959 showed 2,4,5-T at 5 pounds per acre to be as effective as the above treatments.

Note: A mimeographed copy of complete paper is available from the author.

CHEMICAL TREATMENTS FOR THE CONTROL OF LEAFY SPURGE (*EUPHORBIA ESULA*)

Stanford N. Fertig 1/

(A Summary Report)

INTRODUCTION:

Leafy Spurge (*Euphorbia esula*) is a herbaceous, long-lived deep-rooted perennial which reproduces and spreads by seed and underground roots and rhizomes. It has been known in the United States for more than 100 years and has slowly but persistently spread over thousands of acres in at least 25 states and in several Canadian Provinces. The largest infestation in New York at present is in Jefferson County and is estimated at 6,000 acres.

EXPERIMENTAL METHOD AND PROCEDURE:

On August 5, 1958, the chemicals listed in Table I were applied to Leafy Spurge as follows: (1) established stands of Leafy Spurge in the seed stage and (2) regrowth of Leafy Spurge (about 8 inches tall) which had been mowed 4 weeks prior to treatment.

The experimental design was a randomized plot with four replications of each treatment. All chemicals were applied in 30 gallons of water per acre.

RESULTS AND DISCUSSION:

Observations during the spring of 1959 showed a definite thinning of the original plants and a reduction in vigor of new shoots for the better treatments. However, based on shoot counts (Table I) made July 9, 1959, the chemicals used were not effective in controlling Leafy Spurge. The values recorded, which represent shoots of all sizes, include new shoots from roots and rhizomes. The variation from the check is greater on the seed stage plots than on the regrowth plots.

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Table 1. Chemical Treatments and Stand Counts on Leafy Spurge Plots.

Treatment No.	Chemical Used	Rate/A. lbs. A.E.	Average number of shoots/sq. ft* July 9, 1959	
			Seed stage plots	Regrowth plots
1	Ammate - X	600	6.3	14.2
2	Amitrol - T	5	5.3	10.6
3	Check	0	7.4	10.9
4	Amitrol - T	15	4.8	9.6
5	Amino Triazole(P)	5	6.0	7.8
6	Amino Triazole(P)	10	6.7	7.8
7	Amino Tirazole(P)	15	6.0	7.8
8	ACP M-103-A	10	17.0	7.1
9	ACP M-103-A	20	9.3	12.1
10	ACP M-354	10	11.2	10.6
11	ACP M-354	20	8.75	8.5
12	2,4,5-TP	20	7.4	6.6
13	2,4,5-TP	40	9.5	11.3
14	Check	0	9.4	11.3

* Average of 3 - 2 sq ft quadrat counts per plot.

Based on the effectiveness of some chemicals in reducing the initial growth and vigor of Leafy Spurge, a few plots were retreated on July 9, 1959.

Table 2. Retreatments of Leafy Spurge, 1959

1959 Treatment No.	1958 Treatment No.	Chemical Used	Rate/A. 1958	Retreatment Rate/A. 1959
1	2	Amitrol - T	5	5
2	8	Benzac 1281	10	5
3	12	2,4,5-TP	20	5

Visual ratings were made on the retreated plots and those not retreated on May 13, 1960. Theee ratings are shown in Table 3.

Table 3. Visual Ratings and Stand Counts on Leafy Spurge, Zahn Farm

Treatment No.	Chemical Used	Rate/A. lbs. A.E.	Visual Rating* May 13, 1960 Regrowth stage (only)	Stand counts - Av. No. per square foot ** Seed Stage	Regrowth stage
1	Ammate - X	600	4.5	5.4	4.0
2	Amitrol-T (retreated)	5	8.0	0.7	0.7
3	Check	0	0.0	7.0	6.0
4	Amitrol-T	15	2.5	3.0	
5	Amino Triazole (P)	5	6.5	4.0	5.0
6	Amino Triazole (P)	10	3.5	3.9	4.5
7	Amino Triazole (P)	15	4.0	4.3	
8	ACP M-103-A (retreated)	10	6.0	5.2	6.4
9	ACP M-103-A	20	3.0	9.4	5.5
10	ACP M-354	10	5.5	7.0	3.7
11	ACP M-354	20	7.0		
12	2,4,5-TP (retreated)	20	9.0	4.4	0.5
13	2,4,5-TP	40	8.0	5.3	5.0
14	Check	0	0.0	10.5	6.0

* Rating values: 0 = No control
10 = Complete control
** Average of the 4 replicates

On July 10, 1959, a second series of treatments was established on another area of Leafy Spurge in Jefferson County. The chemicals used and rates per acre are shown in Table 4.

Visual ratings were made on these plots on May 12, 1960 and stand counts on September 14 and October 13, 1960. Table 4.

Table 4. Visual Ratings and Stand Counts on Leafy Spurge, Sprague Farm

Treatment No.	Chemical Used	Rate/A. lbs. A.E.	Visual Rating-made May 12, 1960* Sandy soil	Silt loam soil	Stand count -made Sept. 1960** Sandy soil	Silt loam soil
1	2,4,5-TP	5	9.0	5.0	1.1	7.5
2	2,4,5-TP	10	10.0	5.5	2.3	9.0
3	Amitrol-T	5	7.0	4.0	0.6	3.8
4	Amino Triazole (P)	5	7.0	4.0	0.33	2.3
5	Atrazine	5	2.0	1.0	3.0	7.3
6	Benzac 1281	5	7.5	5.5	2.5	6.5
7	Fenac	5	5.0	5.0	3.4	6.1
8	Fenac	10	9.5	7.0	2.3	5.3
9	Check	0	0.0	0.0	6.3	4.4

* Ratings values: 0 = No control
10 = Complete control
** Average of 2 sq. ft. quadrat counts per plot.

Based on the visual ratings and stand counts in Table 4, the control of Leafy Spurge is more readily accomplished on light soils than on heavy soils.

SUMMARY:

The compounds most promising for the control of Leafy Spurge are 2,4,5-TP and Amino Triazole. At least two treatments of either compound are necessary to appreciably reduce the stand of Leafy Spurge.

Note: A mimeographed copy of the complete paper is available from the author.

ANNUAL WEED CONTROL IN SILAGE CORN [1]

Jonas Vengris [2]

This is a progress report of work done in 1960 with herbicides for the control of annual weeds in field corn. The main objective of these trials was to compare the effectiveness of triazines and other new herbicides with Dinitro and 2,4-D.

Procedure:

The experiment was conducted on a fine sandy loam with fair drainage. A randomized block design with three replicates was used. Each plot consisted of four corn rows 25 ft. long. The seedbed was prepared on April 28 and 29. Eleven days later on May 10 pre-planting treatments (Table I) were applied and immediately worked into the soil by rototilling 4-6 in. deep. Two days later on May 12, Ohio M-15 field corn was planted. Pre-emergence treatments were applied on the following day. At this time some small annual weed seedlings had already emerged. Therefore, the pre-emergence treatments should be considered at least partially as post-emergence treatments. In the Randox 4 lb/A + 2,4-D 1/2 lb/A treatment, Randox was applied as a pre-emergence treatment on May 13, and 2,4-D applied on June 10 as a post-emergence treatment. At that time corn was approximately 7 inches high. When making the pre-planting and pre-emergence treatments, the soil was moist. Within a week more rain showers occurred so that weather conditions for the treatments were quite favorable. There was no cultivation during the growing season.

The effect of different treatments on weeds and corn was observed throughout the growing season. The weed population in the order of their relative frequency was made up of the following species: Lambs quarters (Chenopodium album), old witch grass (Panicum capillare), barnyard grass (Echinochloa Crus-galli), pigweed (Amaranthus retroflexus), crabgrass (Digitaria sanguinalis) and carpet weed (Mollugo verticillata).

All herbicide rates presented in Table I are expressed in pounds of acid equivalent or active ingredient per acre.

Results and Discussion:

Observations made ten weeks after planting are recorded in Table I. All treatments effectively controlled dicotyledoneous weeds. With the exception of 1/2 lb/A of 2,4-D as a post-emergence treatment, all herbicides at the rates applied also controlled grassy weeds. 2,4-D applied as a liquid was more effective in controlling broadleaved weeds and also weedy grasses than 2,4-D in granulated form. Randox this year was not as

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effective as in 1959 (1). This could possibly be due to the relatively long interval between seedbed preparation and material application. Weed seedlings in evidence at the time of the Randox applications were not controlled. Once more, the 1960 tests showed that it is sound practice to apply DNBP at emergence or immediately after the emergence of field corn. EPTAM gave excellent control of grassy weeds but broadleaved weed control was significantly poorer. In general, the best annual weed control in our field tests was obtained by triazine treatments. We did not get significant differences between rates, time of application or form of material (Atrazine or Simazine). This is probably due to the satisfactory soil moisture conditions throughout the growing season. Mixing Atrazine and Simazine with the soil immediately after application did not increase their effectiveness. One is inclined to postulate that under dry soil conditions mixing should provide better weed control. Cpd. B, as well as Fenac, performed well in controlling annual weeds but both herbicides caused injury to corn, especially at the 4 lb/A rate.

Summary and Conclusions:

1. A weed control experiment with field corn was conducted on a fine sandy loam soil. Nine different herbicides at various rates and times of application were used. Corn was planted on moist soil and within a week following the application of pre-emergence treatments about one inch of rain fell. The weed population consisted of: lambs quarters, old witch grass, barnyard grass, pigweed, crabgrass and carpet-weed.

2. All chemicals were effective in controlling broadleaved weeds. With the exception of 2,4-D, 1/2 lb/A post-emergence application, all herbicides effectively controlled grassy weeds also. The best weed control was obtained with Atrazine and Simazine. Under the soil moisture conditions which prevailed as little as one lb/A of Atrazine or Simazine gave good annual weed control in field corn. Applying triazines before planting and immediately mixing 4-5 in. deep with the soil was not superior to the pre-emergence applications. Fenac and Cpd. B gave a very good weed control but corn injury was significant. EPTAM 4 lb/A and 6 lb/A rates stunted corn for six weeks. Later on the corn regained normal appearance and yields were significantly higher than the checks.

References:

1. Vengris, Jonas. Weed Control in Field Corn. Proceedings 14th Annual NEWCC, pp. 367-369. 1960.

TABLE I. Field Corn Weed Control and Silage Corn Yields
Relative Values Check = 100

Treatments and Time of Application	Weed Stands 7/21/60 Dicot	Weed Stands 7/21/60 Monocot	Corn Yields 9/15/60
1. Check	100	100	100
2. EPTAM 2 lb/A, pre-planting & mixed in	47	9	150
3. EPTAM 4 lb/A, pre-planting & mixed in	30	4	147
4. EPTAM 6 lb/A, pre-planting & mixed in	28	4	162
5. Cpd. B* 2 lb/A, pre-planting & mixed in	20	13	119
6. Cpd. B* 4 lb/A, pre-planting & mixed in	8	8	65
7. Atrazine 1 lb/A, pre-planting & mixed in	7	7	174
8. Atrazine 3 lb/A, pre-planting & mixed in	1	7	157
9. Atrazine 1 lb/A, pre-emergence	3	8	162
10. Atrazine 3 lb/A, pre-emergence	2	6	151
11. Simazine 1 lb/A, pre-planting & mixed in	14	11	165
12. Simazine 3 lb/A, pre-planting & mixed in	7	6	149
13. Simazine 1 lb/A, pre-emergence	2	3	152
14. Simazine 3 lb/A, pre-emergence	1	2	149
15. 2,4-D 1 1/2 lb/A, LVE, pre-emergence	23	33	151
16. 2,4-D 1 1/2 lb/A, granulated pre-emerg.	77	60	115
17. 2,4-D 1/2 lb/A, Amine, corn 8" tall	6	100	129
18. DNBP 6 lb/A, pre-emergence	23	38	140
19. DNBP 3 lb/A, spike stage	25	24	158
20. Fenac 2 lb/A, pre-emergence	11	6	129
21. Fenac 4 lb/A, pre-emergence	14	6	112
22. Randox 4 lb/A, pre-emergence	52	48	119
23. Randox** 4 lb/A + 2,4-D 1/2 lb/A	13	40	154
24. Randox-T 3 lb/A (CDAA), pre-emergence	22	32	150
L.S.D. at 5% level	15	19	29
L.S.D. at 1% level	20	25	38

*Cpd. B is Na-Salt of 2-methoxy-3,6-dichlorobenzoic acid by Velsicol Company
**Randox applied as pre-emergence May 13 & 2,4-D as post-emergence June 10.

CHEMICAL QUACKGRASS CONTROL[1]

Jonas Vengris[2]

This is a progress report of work done in 1959/60 with herbicides for quackgrass (Agropyron repens) control.

Amherst,Mass. Experiment:

Trials were conducted on a fine sandy loam with fair drainage. The experimental area had a good uniform stand of quackgrass. It was also infested with nutgrass (Cyperus esculentus); however, the stand of nutgrass was not too uniform. Plots were 12x25 feet in size. Two replicates were used. In the fall of 1959 treatments were applied on October 15 on a lush 8 inch growth of quackgrass. In the fall treatments, dalapon, atrazine and simazine were used. In all tables, rates are expressed as acid equivalent or active ingredient per acre. Five days after the application of herbicides, the experimental area was irrigated with 3/4 in. of water.

By December 3, quackgrass plants treated with dalapon and atrazine were stunted and chlorotic. Simazine was less effective. On May 6, following, quackgrass stands were again surveyed. The results are shown in Table I. In general all treatments were effective in suppressing quackgrass.

Spring treatments of dalapon and Fenac were applied on April 28 on 8 in. growth of quackgrass. On May 16 the whole experimental area was plowed, disked, fertilized and the seedbed prepared for planting corn. EPTAM, Atrazine and Simazine were applied as spring treatments on May 20. Three days later, May 23, Ohio M-15, silage field corn was planted. On some treatments (Table I), the applied herbicides were immediately disked in 4-6 in. deep. The following night 1/2 in. of rain fell. To control annual weeds, the whole experimental area was treated on June 2 with 3 lb/A of DNBP. No cultivation was done. Quackgrass stand estimates were made on July 28 and again on September 15 (Table I) following corn harvest.

The treatments applied in the fall of 1959 gave excellent quackgrass control with Atrazine being the most effective. There was little observable difference between the different rates used. During the growing season all the fall treatments became infested with nutgrass. The lush growth of nutgrass suppressed quackgrass and thus indirectly increased the effectiveness of fall treatments in controlling quackgrass. No one herbicide applied in the fall significantly controlled nut grass. Of the spring treatments, the best quackgrass control was obtained with Atrazine. Mixing the applied Atrazine immediately with the soil slightly increased its effectiveness. The best nutgrass control was obtained with both rates of EPTAM and Atrazine, and the poorest with dalapon and Fenac.

Corn was slightly stunted by Fenac and 6 lb/A of EPTAM. Later on corn in these plots regained normal growth.

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Sunderland, Mass. Experiment:

In this experiment, trials were conducted on a well drained gravelly sandy loam. The area was heavily and uniformly infested with a quackgrass sod which had not been tilled for three years. On April 14 the area was plowed 6-7" deep and disked. Treatments 2,3,9,10,15,16 were applied on May 19 (Table II). There were two replicates. At that time quackgrass was about 6 in. tall. Six days later on May 25, the whole area was plowed, disked, fertilized and the seedbed prepared. On May 26 all pre-planting treatments were applied and the herbicides in treatments 4,5,6,7,8,11,12, 17 and 18 were immediately disked into the soil. On May 27 Ohio M-15 silage corn was planted. Four days later, on May 31, 0.75 inches of rain fell. On June 2 the whole experimental area was sprayed with 6 lb/A of DNBP to control annual weeds. During the growing season the corn was not cultivated. Quackgrass stand estimates made on July 26 are shown in Table II.

In general, the best quackgrass control was obtained with both Triazines and EPTAM. Atrazine provided better control than comparable rates of Simazine. Mixing in the applied Atrazine or Simazine with the soil slightly increased their effectiveness. Relatively poor control was obtained from spring applications made on quackgrass foliage, possibly due to the fact that sod was plowed under early the same spring. Some of the rhizomes, which were turned under, did not produce shoots and therefore did not come into contact with materials applied on the foliage. Some of these rhizomes were exposed during seedbed preparation and produced a healthy growth of quackgrass. Corn was injured by both Fenac treatments. Mixing Fenac with the soil significantly increased its effectiveness in controlling quackgrass. However, injury to the corn was also increased even to the point of depressed yields.

Leverett, Mass. Experiment:

In this experiment, trials were conducted on a well drained gravelly sandy loam. The area had a good uniform stand of quackgrass. Plots were 12 ft. by 30 ft. Five replicates were used. In this experiment we used in all treatments 5 lb/A of actual Atrazine. Treatments 2 and 3 were applied April 28 on 6 in. tall quackgrass (Table III). Treatment 3 was rototilled about 5 in. deep following application of materials. The same day treatments 4 and 5 were also rototilled. Close observations showed that this rototilling cut the rhizomes into 3-6 inch segments. On May 16 the experimental area was plowed, disked, fertilized and prepared for planting. By this time, plots which had been rototilled on April 28, had a thick re-growth of quackgrass. It appeared that rototilling had activated dormant rhizome buds (1) and produced more shoots. It was postulated that this practice would provide better absorption of Atrazine and finally provide a better control of quackgrass. Atrazine was applied on treatments 4, 5, 6 and 7 on May 20. According to the plan (Table III) treatments 5 and 7 were rototilled immediately after application of the herbicide. Silage corn Ohio M-15 was planted on all treatments on the same day, May 23. From May 23 into May 24, 0.52 inches of rain fell. It seems that soil moisture conditions were favorable for Atrazine. On June 2 the whole experimental area was sprayed with 3 pounds per acre of

DNBP. Quackgrass stand estimates were made on June 14, July 26 and finally at harvest time on September 16. Quackgrass control as well as corn yield data are presented in Table III.

Throughout the growing season treatments 3,4 and 5 gave by far the best quackgrass control. Rototilling early in the spring on April 28 indirectly increased the activity of Atrazine. Rototilling cut the rhizomes into relatively short pieces and encouraged them to produce shoots thereby using up nutrient reserves. (2). Plowing when preparing seedbed might also help to kill the exhausted rhizomes. Atrazine applied on non-rototilled plots (treatments 6 and 7) suppressed quackgrass much more slowly. Results from this experiment confirmed our Amherst and Sunderland experiment results that mixing the applied triazines immediately after applications with the soil increases quackgrass control. But contrary to the Sunderland results, early spring Atrazine application on the foliage was quite effective (cf. treatments 2 and 6). Check plots produced a heavy growth of quackgrass which strongly competed with corn for plant nutrients and especially for water. All treatments increased silage corn yields significantly.

Summary and Conclusions:

In the scope of this paper we present results of three field experiments conducted in 1959-60 in Massachusetts. The results warrant the following conclusions.

1. Atrazine is most promising and effective in controlling quackgrass in field corn. A rate of 3-5 lb/A of active ingredient is suggested. Atrazine can be applied early in the spring on quackgrass foliage or at planting time on a well prepared seedbed. In both cases mixing the applied Atrazine immediately with the soil is recommended. Cutting rhizomes early in the spring by rototilling quackgrass sod increases the effectiveness of Atrazine.

2. EPTAM is also promising in controlling quackgrass in field corn. Suggested rates are 4-6 lb/A. Slight corn stunting may occur but corn yields were not usually affected. More tests should be conducted.

References:

1. Johnson, B.G. Natural and Induced Dormancy of the Vegetative Buds on the Rhizomes of Quackgrass (Agropyron repens (L.) Beav.). Ph.D. Thesis, University of Wisconsin, 1958.

2. P.P. Zaev, N.G.Zhezhel, M.P. Fyodoseeva. Obchshee Zemledelie Selhozgiz Moskva, Leningrad 1957 (Russ.)

TABLE I. Quackgrass Control in Field Corn
Amherst, Massachusetts
Relative Values Check = 100

	Treatments	Time of Application	Quackgrass Stand 5/6/60	7/28/60	9/15/60
1.	Check		100	100	100
2.	Dalapon 4 lb/A on 8 in. foliage	10/15/59	9	15	22
3.	Dalapon 8 lb/A on 8 in. foliage	10/15/59	4	14	14
4.	Atrazine 4 lb/A on 8 in. foliage	10/15/59	9	5	12
5.	Atrazine 8 lb/A on 8 in. foliage	10/15/59	7	5	10
6.	Simazine 4 lb/A on 8 in. foliage	10/15/59	18	13	10
7.	Simazine 8 lb/A on 8 in. foliage	10/15/59	9	15	15
8.	Dalapon 4 lb/A on 8 in. foliage	10/15/59			
	+ Atrazine 4 lb/A pre-pl.	5/20/60	12	15	8
9.	Dalapon 8 lb/A on 8 in. foliage	4/28/60	-	40	38
10.	Fenac 4 lb/A on 8 in. foliage	4/28/60	-	70	75
11.	EPTAM 4 lb/A, pre-pl. and disked in	5/20/60	-	36	46
12.	EPTAM 6 lb/A, pre-pl. and disked in	5/20/60	-	33	40
13.	Atrazine 4 lb/A, pre-pl.	5/20/60	-	25	18
14.	Atrazine 8 lb/A, pre-pl.	5/20/60	-	20	17
15.	Atrazine 4 lb/A, pre-pl. and disked in	5/20/60	-	12	7
16.	Atrazine 8 lb/A, pre-pl. and disked in	5/20/60	-	10	4
17.	Simazine 4 lb/A, pre-pl.	5/20/60	-	27	24
18.	Simazine 8 lb/A, pre-pl.	5/20/60	-	20	24

TABLE II. Quackgrass Control in Field Corn
Sunderland, Massachusetts
Relative Values Check = 100

Treatments	Time of Application	Quackgrass Stand 7/26/60	Corn Yields
1. Check		100	100
2. Dalapon 8 lb/A on 6" foliage	5/19/60	60	139
3. Fenac 4 lb/A on 6" foliage	5/19/60	72	130
4. Fenac 4 lb/A, pre-pl. and disked in	5/26/60	30	98
5. EPTAM 4 lb/A, pre-pl. and disked in	5/26/60	32	150
6. EPTAM 6 lb/A, pre-pl. and disked in	5/26/60	24	181
7. 2061* 4 lb/A, pre-pl. and disked in	5/26/60	70	150
8. 2061* 6 lb/A, pre-pl. and disked in	5/26/60	73	131
9. Atrazine 3 lb/A on 6" foliage	5/19/60	40	157
10. Atrazine 6 lb/A on 6" foliage	5/19/60	30	166
11. Atrazine 3 lb/A, pre-pl. and disked in	5/26/60	21	167
12. Atrazine 6 lb/A, pre-pl. and disked in	5/26/60	8	173
13. Atrazine 3 lb/A, pre-pl.	5/26/60	21	185
14. Atrazine 6 lb/A, pre-pl.	5/26/60	15	192
15. Simazine 3 lb/A on 6" foliage	5/19/60	52	137
16. Simazine 6 lb/A on 6" foliage	5/19/60	38	156
17. Simazine 3 lb/A, pre-pl. and disked in	5/26/60	32	171
18. Simazine 6 lb/A, pre-pl. and disked in	5/26/60	18	156
19. Simazine 3 lb/A, pre-pl.	5/26/60	34	170
20. Simazine 6 lb/A, pre-pl.	5/26/60	20	176

*2061 = propyl ethyl-n-butylthiocarbamate by Stauffer Chemical Company

TABLE III. Quackgrass Control in Field Corn
Leverett, Massachusetts
Relative Values Check = 100

Treatments	Quackgrass Stand 6/14/60	7/26/60	9/16/60	Corn Yields
1. Check	100	100	100	100
2. Atrazine 5 lb/A on 6" foliage on 4/28/60	22	16	19	136
3. Atrazine 5 lb/A on 6" foliage on 4/28/60 and rototilled	12	8	2	140
4. Rototilled 4/28/60, Atrazine 5 lb/A at planting on 5/20/60	8	5	5	139
5. Rototilled 4/28/60, Atrazine 5 lb/A at planting on 5/20/60 and rototilled	8	1	1	140
6. Atrazine 5 lb/A at planting on 5/20/60	60	27	28	145
7. Atrazine 5 lb/A at planting on 5/20/60 and rototilled	50	13	11	146
L.S.D. at 5% level	9	6	6	17
L.S.D. at 1% level	12	8	8	23

NUTGRASS CONTROL WITH ATRAZINE AND EPTAM IN FIELD CORN IN 1960[1]

Jonas Vengris[2]

Nutgrass (Cyperus esculentus L.) is a common perennial weed in Massachusetts. In the last few years this weed has been increasing and has become one of the most noxious pests.

The objective of our tests was to determine the possibilities of controlling nutgrass with Atrazine and EPTAM in field corn.

Procedure:

The experiment was conducted on a fine sandy loam with fair drainage. The area had a good and uniform stand of nutgrass. A randomized block design with four replicates was used. Each plot consisted of four field corn rows 25 ft. long. All treatments were applied on May 31. Immediately after application, EPTAM and the first three treatments of Atrazine (Table I) were disked in 4-6 in. deep. When applying the herbicides, the soil was moist and the next day 3/4 in. of rain fell. One is inclined to think that soil-weather conditions for Atrazine were excellent. On June 1, Ohio M-15 silage corn was planted. To control annual weeds on check plots, the whole experimental area was sprayed on June 2 with 6 lb/A of DNBP. A heavy washing rain occurred on June 15 and all plots were cultivated with a tractor mounted cultivator on June 17 to fill in gullies.

All herbicide rates presented in Table I are expressed in pounds of acid equivalent or active ingredient per acre.

Results and Discussion:

The effect of different treatments on nutgrass and corn was observed during the entire growing season. Observations made four weeks and eight weeks after planting are recorded in Table I. Two middle rows of each plot were harvested as silage corn on September 14. All herbicides at all applied rates gave highly significant control of nutgrass. Some corn stunting was observed with the two highest EPTAM rates but this did not seem to affect yields. No significant differences between the three rates of EPTAM were observed. The action of EPTAM is rather rapid and our results (Table I) indicate that weed control four weeks after planting was as good as eight weeks after planting. On the contrary with Atrazine, nutgrass control on July 29 was much better than on July 1. Mixing applied Atrazine with soil immediately after application did not increase nutgrass control. This probably was due to the heavy rain shortly after application of the

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herbicides. In general, we had a rather rainy spring and summer in Massachusetts. Plots treated with Atrazine were free from annual broad-leaved as well as grassy weeds throughout the growing season. Plots treated with EPTAM became infested with pigweed (Amaranthus retroflexus) during late season. It is possible that excessive rain shortly after application of the herbicide decreased its effectiveness. Last year excellent broad-leaved weed control was obtained with 4 lb/A and 6 lb/A of EPTAM in field corn (1).

Because of good nutgrass control by all herbicides and at all rates applied, yields of silage corn were significantly increased. No significant differences were noted between herbicides or rates applied.

On the basis of one year's results it would appear that good nutgrass control can be had from 4 lb/A of Atrazine or EPTAM. Atrazine is slightly more effective and does not affect corn plants.

Summary and Conclusions:

1. One year's field tests indicate that Atrazine is effective and promising in controlling nutgrass (Cyperus esculentus). A rate of about 4 lb/A is suggested. Applications should be made in the spring immediately before the planting of corn. Mixing applied herbicide with soil to a depth of 4-6 in. is advantageous especially if dry weather and soil conditions are anticipated. Atrazine can be applied at planting or as a pre-emergence treatment for corn.

2. EPTAM is also promising for controlling nutgrass in field corn. Suggested rates are 4-5 lb/A. This chemical should be applied before planting and immediately incorporated 4-6 in. deep in soil by disking. For two consecutive years some corn stunting resulted from 4 lb/A of EPTAM (1) but later on plants regained normal appearance and yields were significantly better than checks.

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1. J. Vengris. Weed Control in Field Corn. Proc. 14th An. NEWCC, 367-69. 1960.

TABLE I. Nutgrass Control in Field Corn
Relative Values. Check - 100

Treatments	Nutgrass Stand 7/1/60	Nutgrass Stand 7/29/60	Corn Yields
1. Check	100	100	100
2. EPTAM 4 lb/A, pre-pl., disked in	23	24	131
3. EPTAM 6 lb/A, pre-pl., disked in	22	22	131
4. EPTAM 8 lb/A, pre-pl., disked in	16	18	128
5. Atrazine 2 lb/A, pre-pl., disked in	50	37	123
6. Atrazine 4 lb/A, pre-pl., disked in	27	16	133
7. Atrazine 8 lb/A, pre-pl., disked in	23	7	131
8. Atrazine 2 lb/A, pre-pl.	40	32	124
9. Atrazine 4 lb/A, pre-pl.	31	18	124
10. Atrazine 8 lb/A, pre-pl.	19	6	136
L.S.D at 5% level	10	8	17
L.S.D. at 1% level	15	11	23

Pre-emergence Crabgrass Control in Maryland[1]

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Crabgrass (Digitaria spp) is a universal lawn weed pest throughout Maryland. Until recently, practical control of these species was limited to the use of contact herbicides after the weed had emerged (post-emergence). Unfortunately, Kentucky bluegrass, the dominant lawn species in Maryland, is susceptible to these materials if they are applied improperly. Recently, several materials have been developed for use before the crabgrass has emerged (pre-emergence). However, the efficiency of pre-emergence herbicides is materially affected by climatic and soil environmental conditions. Thus, these materials need to be tested in Maryland before they can be recommended to the many homeowners of this state.

MATERIALS & METHODS

Plots were established in 4 replications at several locations in Maryland in 1959 and 1960. Treatments were all applied in established Kentucky bluegrass lawns, before crabgrass had germinated. In all instances, there was some rainfall within one week of the treatment date. The dates and locations were as follows:

A. Treated Nov. 11, 1958, near Beltsville.
B. Treated Mar. 20, 1959, College Park.
C. Treated Dec. 3, 1959, College Park.
D. Treated Mar. 28, 1960, College Park.
E. Treated Mar. 29, 1960, near Clarksville.

All treatments were applied to 2 to 3" bluegrass. At location D there was a heavy Pon annua stand, at E there was a heavy clover stand.

The materials used were:

Chlordane, 10% and 20% granular and 75% emulsifiable concentrate
Dacthal, 50% wettable powder
Zytron, emulsifiable concentrate or granular form
Calcium Arsenate, granular, 73% active ingredient
Pax, primarily lead arsenate and chlordane
No-Crab, a calcium arsenate and 2,4-D mixture

Herbicides applied as a spray were in ¼ to ½ gallons of water per 100 square feet. Granular materials were applied with a calibrated spreader.

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RESULTS & DISCUSSION

In August of 1959 or 1960 the plots were rated as to percent control of the crabgrass. The results are reported in Table 1 for all materials except the various Calcium Arsenate compounds.

No treatment resulted in serious turf injury except the Pax at location A. Here the bluegrass was noticably thinned out. Pax also caused some turf thinning at location B. Granular Zytron at 20 lb/A also caused slight turf injury at locations C & D, as did "No-Crab" at location D.

There was considerable variation between the various calcium arsenate compounds. They also varied widely from one location to another. For example, "No-Crab" resulted in 98% control at location D, and 44% at location E. In general, control was fairly good with the calcium arsenate materials.

Table 1. Late Summer Control of Crabgrass with Various Pre-emergence Herbicides

Tmt.	Rate #/A	A	C	Av. Fall Tmts.	B	D	E	Av. Spring Tmts.	Av.
				% Control					
Chlordane									
10%	75	62	12	37	78	55	65	66	54
" 20%	60	27	20	24	30	25	30	28	26
" 75%	75	50	--	--	40	55	23	39	42
Zytron-e.c.	15	--	79	--	67	85	78	77	77
" "	20	--	89	--	85	84	91	87	87
" gran.	15	--	83	--	70	95	83	83	83
" "	20	--	73	--	72	99	85	85	82
Dacthal, w.p.	5	48	20	34	83	70	75	76	74
" "	10	70	68	69	88	93	96	92	83
PAX 1080		87	--	--	80	85	--	83	84
Untreated Ck		0	0	0	0	0	0	0	0

Locations A and C were treated in the fall or early winter; the others were late March treatments. The Chlordane treatments were somewhat more successful when applied in the spring than when applied in the fall. The same was even more true of the Dacthal treatments.

Over-all, the Chlordane treatments were the least successful. Dacthal, Zytron & Pax resulted in good crabgrass control. Little difference was found between the granular & the spray forms of Zytron. Dacthal & Zytron treatments were more successful than Pax, in that Pax injured the turf.

SUMMARY

Herbicides were applied to established Kentucky bluegrass turf in 1958, 1959, and 1960 for pre-emergence crabgrass control. The use of Chlordane resulted in relatively poor control, the 10% granular form being better than a 20% granular or the 75% emulsifiable concentrate.

"Pax" resulted in good weed control, but caused severe turf injury. Zytron and Dacthal controlled 75 to 90 percent of the crabgrass. There was little difference between the granular and the liquid forms of Zytron. Dacthal was more satisfactory as a spring treatment than as a fall application.

WHAT HAPPENS TO PHENOXY HERBICIDES WHEN APPLIED TO A WATERSHED AREA

by

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Water supply people responsible for maintaining reservoirs of wholesome water frequently ask about the effects on water quality when brush in the surrounding watershed areas is chemically sprayed. What are the breakdown products and how might they affect water supplies are two of the questions sanitary engineers ask concerning phenoxy herbicides.

No discussion will be made here regarding the direct toxicity of 2,4-D and related materials. The wide use of 2,4-D, 2,4,5-T and similar compounds over many years now provides excellent practical assurance of the lack of toxicity. Discussed here will be the products of decomposition by soil microflora and their effects on water supplies.

A. MICROBIAL DEGRADATION

Bacterial decomposition of 2,4-D, 2,4,5-T, silvex and related chemicals is well reported in the literature. At least eight species of bacteria are known to feed actively on chlorinated phenoxy herbicides. Corynebacterium sp. (8) decomposed 80% of a 1,000 parts per million (ppm) concentration of 2,4-D in four hours, releasing chlorine as the free chloride ion. Bacterium globiforme (1), which is readily found in garden and woods soils, Flavobacterium aquatile (5) and F. peregrenum (12), two species of Achromobacter (2, 12), and a Mycoplana sp. (14) all have been identified as capable of destroying phenoxy compounds. Work conducted by the senior author of this paper shows still another species of bacterium that feeds actively on phenoxy compounds. This bacterium has been identified as Pseudomonas cruciviae, and is one whose source of isolation and habitat is soil (3). P. cruciviae fed equally as well on 2,4-dichlorophenol, pentachlorophenol, and unsubstituted phenol.

The hypothesis has been made that soil and water bacteria would convert 2,4-D, 2,4,5-T and related chemicals back to di- and trichlorophenols (2,4). Both of these free phenols can cause taste and odor problems in extremely low concentrations. A study was undertaken to evaluate this hypothesis and to positively determine the end decomposition products formed after exposure to bacterial action.

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B. PROCEDURE

Laboratory apparatus used in these experiments consisted mainly of a source of supply of phenoxy solutions, an aerator, (since biological oxidation by previously mentioned species of bacteria occurs generally under aerobic conditions) a settling chamber and a proportioning pump to provide continuous feed at a set rate. The effluent solutions were collected and chemically analyzed to determine components or degradation products.

Seeding of the aerator to obtain phenol digesting bacteria was done in two ways. Activated sludge from an industrial waste treatment plant which treats both sanitary and industrial wastes, provided bacterial "seed" for half of the test equipment. However, since bacteria which decompose these compounds are reported to be found generally in nature (3, 6, 9, 13), a collection of soil samples was gathered from a typical watershed area and used for comparison in the other half of the laboratory setup. These watershed soil samples were taken from areas on which no prior application of any herbicides has been made.

C. RESULTS

Known amounts (i.e., 55 ppm) of phenoxy herbicides were fed to the influent of the systems. After 30-hour exposures to the bacterial cultures, effluent samples were removed and exhaustively analyzed. Beside odor and taste threshold tests, the Gibbs test to determine free phenols with a sensitivity of 10 parts per billion (ppb) was used. Furthermore, to increase this sensitivity, after color formation with the Gibbs method, a further solvent extraction was made so as to concentrate color and thus increase sensitivity of the test. With the analytical tests then having a sensitivity of 0.5 ppb, no free phenols were detectable. Microflora from either the general waste seeding or from watershed soil samples had decomposed the phenoxy compounds to carbon dioxide, inorganic chlorides and water. A quantitative release of the chloride ion had occurred during the bacterial decomposition (11). In the effluents there was no detectable dichlorophenol nor trichlorophenol residue. The oxygen consumption was that which theoretically would be required to affect complete oxidation. Free phenols as such were also introduced into the system for further tests on biological oxidation. The phenols were reduced in a similar manner.

Confirmation of this work with regard to 2,4-D has been reported by Rogoff and Reid (8). Their summary states, "An organism . . . . . . *Corynebacterium* sp. . . . . decomposes 2,4-D acid in relatively large amounts in synthetic medium. Indications are that complete destruction of the molecule follows ring rupture."

D. TASTE AND ODOR STUDIES

Taste and odor threshold studies have been conducted on the herbicide formulations as such. These studies show that the ester, acid and amine formulations have higher odor and taste thresholds than the corresponding free phenol counterparts. However, since it already has been shown that free phenols are not the end breakdown products of formulations after exposure to bacterial action, additional studies were conducted on the component parts of these formulations.

The odor threshold of Esteron* 245 O.S. herbicide is about 0.3 ppb and the taste threshold is about 1.3 ppb. These figures are very low, but are not due to the 2,4,5-T ester but rather to the oil used in formulation. This oil is typical of that used commonly in agricultural sprays and is believed to be readily oxidized (decomposed) by soil bacteria, as we shall see later. Further, the odor threshold of the 2,4,5-T propylene glycol butyl ether ester (PGBE) is about 0.4 ppm. In other words, about 1,300 times more of the ester is required to cause odor than the oil alone. A similar figure gives as great a margin of safety for taste threshold for 2,4,5-T PGBE ester.

E. INFLUENCE OF OIL COMPONENTS

Since analysis of the components of various phenoxy ester formulations has shown that the oil fractions can cause off-taste and odor, what factors can minimize possible watershed contamination? First of all, oils can be altered naturally in many ways. Bacterial action is known to act rapidly on aromatic oils (13). Ludzack and Kinkead (6) reported biochemical oxidation of motor oils by organisms found abundantly in nature and they showed that the principal end product of oil oxidation is CO_2. This conclusion had also been reached earlier by Ruchhoft and associate workers (10). To substantiate this fact, oil components of the herbicide formulations were also run through the laboratory apparatus in experiments similar to those described above. Bacterial decomposition readily and completely oxidized the aromatic oils to CO_2.

Volatilization of aromatic oils is well known (7). Undoubtedly, adsorption to and chemical reaction with soil particles does occur and would further enhance rapid breakdown of oil constituents.

Another aid in decreasing the possibility of watershed contamination by oils would be by the use of herbicide formulations that do not contain oils. Amine salt formulations do not

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have aromatic oils in them. Moreover, they also are decomposed to CO_2, free chlorine and water by bacteria in the same manner as esters and acids.

F. NO PROBLEMS UNDER PRACTICAL USE ON WATERSHEDS

However, even ester formulations produced by reputable manufacturers can be used with safety in watershed areas. For example, let us presuppose a rectangular lake 100 acres in size, having shoreline dimensions of 1,000 feet by 4,356 feet. If a watershed manager wanted to spray a 20-foot wide strip of brush around this shoreline, he would be spraying a total of five acres of brush. Assuming he would apply a herbicide concentration of one gallon of a four pound acid equivalent formulation per 100 gallons of water and this solution were applied at approximately 200 gallons of total spray solution per acre, then on this five acres of brush he would apply 1,000 gallons of total spray which would contain 40 pounds of 2,4,5-T acid equivalent.

Now, if this 100-acre lake had an average depth of 10 feet, it would contain 1,000 acre feet of water. In order to have enough 2,4,5-T ester in the lake to reach an odor or taste threshold, that is, be detectable, 0.4 ppm of the PGBE ester would have to be present. In this example, 1,086 pounds of the 2,4,5-T ester would be needed to reach the odor threshold, 17.7 times more ester than is being applied to the five acres of brush. The oil components, because of a much lower threshold rating, could possibly be troublesome if extremely careless application were made. In this case, more than 110 gallons of the spray solution would have to fall directly into the lake before an odor threshold would be reached. Using proper application techniques, only a very small portion of the spray could conceivably reach the water directly, thus virtually eliminating any possibility of pollution. Of course, where brush control spray applications are applied deeper into the watershed and farther away from the water reservoir, such treatments would present even less hazard of contamination.

G. SUMMARY

Studies of the degradation products of 2,4-D, 2,4,5-T and silvex have been made. The results of these studies show conclusively that decomposition under natural conditions does <u>not</u> result in the formation of the corresponding phenols. These phenoxy herbicides are decomposed into carbon dioxide, hydrochloric acid and water. Free phenols are decreased, rather than increased, by bacterial degradation and are not the breakdown products of phenoxy herbicides. Bacterial oxidation of phenoxy herbicides produces a quantitative release of chloride ions. Aromatic oils have a much lower taste and odor threshold than the active ingredients in reputable phenoxy herbicide formulations. These oils, however, are decomposed even more rapidly than the phenoxy components. Therefore, reputable commercial formulations properly applied to watershed areas do not constitute a water pollution hazard.

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A DECADE OF BRUSH CONTROL

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During the past decade we have conducted an extensive research program in right-of-way maintenance, which has resulted in the experimentation and use of almost every known method, technique, chemical, and type of equipment for brush control.

Brush control is a major and expensive recurring problem connected with the transmission of electric energy in the Tennessee Valley region because of the numerous species of brush and types of terrain, which vary from swamps and rolling upland to high plateaus and rugged mountains. The average annual rainfall is more than 50 inches, and the average annual temperature is above 60°. These factors contribute to luxuriant growth of vegetation. The TVA power system included approximately 12,000 miles of energized transmission lines at the end of June 1960. About 60 percent of the transmission line rights-of-way run through wooded areas, resulting in approximately 90,000 acres of brush to be controlled. The right-of-way width varies from 50 to 600 feet, depending on the voltage and the number of circuits; however, the vast majority of rights-of-way are cleared 100 feet wide.

In the large integrated right-of-way maintenance program associated with TVA's growing power system, there is a place for mechanical and chemical brush control procedures utilizing many different methods and equipments.

Mechanical Maintenance

Until recent years mechanical methods were the only effective means of controlling brush, and even now many utility rights-of-way are maintained only by mechanical methods. The hand method requires large crews using brush hooks, Kaiser blades, and axes for periodically clearing the brush. It is usually necessary to reclear every 2 to 4 years. Because of rising labor costs, the unit cost for the hand method has become increasingly prohibitive, and improved mechanical devices have evolved. Rotary brush cutters, having a 3-point hydraulic lift, pulled by small tractors have been used. However, their use is limited to comparatively level rights-of-way having only small brush. They cannot be used in rocky or mountainous terrain, and they will not clear the brush uniformly close to the ground. These machines can be advantageously used for cutting patrol paths where the ground cover consists of briars, weeds, and small brush.

The Bushwacker has been successfully used by some utility companies and has been tried by TVA. This is a large, self-propelled machine having a large metal drum with flails attached. This machine pushes and/or cuts brush up to 8 inches in diameter in a 6-foot swath along the rights-of-way. The drum is located on the front of the machine and is driven by a separate motor at a high rate of speed. The flails splinter the brush to small pieces, cutting the stumps flush with the ground and leaving them splintered. The equipment used by TVA was underpowered and could climb only about a 15-percent slope, which is not adequate for this region. Also, it was too wide and heavy for the bridges on country roads that it had to travel. The equipment was moved on a large tractor-trailer unit. Rocks kept the spikes broken off, and the services of a welder were required with the machine. Across our rough, rocky terrain the operator did not cut as close to the ground as was desirable; and of course during the next growing season there were several sprouts for each bush cut the previous year. The growth was vigorous, apparently as a result of the established root system.

Power saws with clearing attachments have been used during the past 4 years and have proved to be a very effective and practical mechanical clearing method. These are 1-man saws, and brush up to 5 inches in diameter may be cut from a standing position. Because of the clearing attachments, these saws do a highly satisfactory job where mechanical methods are employed.

Chemical Maintenance

In the early 1940's leading chemical companies, after extensive experimental work, had faith enough in the so-called growth-regulating chemicals to place them on the market. In the latter part of the 1940's TVA became interested in these chemicals and established experimental plots on some of its rights-of-way. Chemicals were applied in accordance with the manufacturers' directions. Evaluation of this work showed enough promise to continue experiments on a large scale. For the first few years low-volatile esters containing 2 pounds of 2,4-D and 2 pounds of 2,4,5-T acid a gallon were used. These were mixed with water as a carrier at the rate of 1 gallon of esters, or 4 pounds acid equivalent, in 100 gallons of water and applied at the rate of 300 to 500 gallons of mixture an acre for foliage spraying by ground crews using hand guns. The brush was thoroughly wet; and the amount of mixture depended on the density, height, and species.

For the past several years, after extensive experimental work, 2,4,5-T esters only have been used. Also nonvolatile Ammate (95-percent ammonium sulfamate) at the rate of 60 pounds in 100 gallons of water with 4 ounces of spreader-sticker acid added was applied at the rate of 300 to 500 gallons of mixture an acre, depending on the height, species, and density of the brush being sprayed. During the early years if the weather was dry during the latter part of July and August, we would add 10- to 20-percent diesel oil to an ester-and-water mixture for foliage application. However, this procedure has been discontinued, along with many other ideas tried during the early years of chemical brush control.

A wide variety of equipment has been used during this period for chemical right-of-way maintenance. The knapsack sprayer has been used to some advantage, but experience has proved that this method has only limited use in a program the size of TVA's. The first spray units purchased were 15-gpm pumps used with 200-gallon tanks. The second units purchased were 20-gpm pumps used with the same 200-gallon capacity tanks. In order to treat brush in remote areas, frequently the crews pumped the spray mixture through a 1/2-inch high-pressure, agricultural spray hose for a distance of as much as 1 mile. Because of this, the next units purchased were 35-gpm pumps used with 500-gallon tanks. The 35-gpm pumps permitted the use of several spray guns with each unit while still maintaining the desired nozzle pressure. The 200-gallon units were skid-mounted on 4-wheel drive vehicles and were very satisfactory. The 500-gallon units were permanently mounted on Army-surplus 6x6 vehicles, and have given excellent service. Normally a crew used 2 spray trucks, 1 water truck, and a personnel carrier. We found that while spraying in remote areas where a considerable amount of hose pulling was required only one 35-gpm pump mounted on a 500-gallon tank was adequate and, of course, more economical.

About 5 years ago we purchased an orchard blower with fans producing a wind velocity up to 90 miles an hour and mounted this on one of our 35-gpm spray units with a 500-gallon tank. Numerous test plots were established with this unit, and some of the results were very satisfactory. However, the timber burned outside the rights-of-way; and the potential hazard to susceptible agricultural and garden crops, particularly on windy days, was so great that we have discontinued the use of this machine.

By 1958 the cost of chemical control had become so great that we were forced to reevaluate our entire program to keep costs down. This reevaluation revealed that we had increased our volume of material per acre in an effort to obtain a higher percentage of brushkill and also that the cost of labor and transportation had skyrocketed. In recent years the trend of control has become centered around individual species to determine their habits, characteristics, and life cycles. From observation it appeared that we were using excessive amounts of chemicals on some species and were overloading the translocation capacity of these plants. We began looking for new methods to apply controlled amounts of chemicals to brush on rights-of-way.

As a result the automatic spray nozzle was developed in 1958 for applying a semiconcentrated mixture of esters and water to transmission line rights-of-way. Available literature was reviewed; and Boomjet, or automatic spray, nozzles were purchased. These were single, compact nozzles made in different capacities for mounting at the rear of a truck for spraying a swath 38 to 66 feet wide, depending on the pressure and gpm. The nozzle assembly produces a uniform flat spray pattern. A telescoping attachment was designed for mounting the nozzle at a vertical angle of 45° to the rear of the truck tank, permitting the nozzle to give a vertical spray pattern at the desired height, which is governed by the height of brush being sprayed. Atomization of each jet is as fine as possible in relation to the distance the spray mixture must travel to complete the spray pattern. The nozzle is brass, with 5 fixed-position tips. It has a 1/4-inch plug in the top, which is an ideal location for a pressure gauge.

We have approximately 20 automatic spray nozzles mounted on military-type 6x6 trucks equipped with no-spin differentials, mud-grip tires, and 800-, 1,000-, and 1,200-gallon tanks. We have been using this type of truck for right-of-way maintenance for several years, and an experienced driver can cover a high percentage of our transmission line rights-of-way sprayed by ground crews with very few acres of brush skipped. A pump with 6 full floating nylon rollers to force the spray mixture through the pump is mounted on the truck frame under the tank and is operated by a power takeoff. The normal operating speed is 500 rpm, and at 20 psi the pump delivers 30 gallons a minute. A pressure gauge, strainer, and adjustable bypass valve are installed. Since no agitator is installed in the tank, the bypass connection is used to keep the water and chemicals mixed.

On a 100-foot right-of-way the truck is driven down one side with the spray directed to the outside edge of the cleared right-of-way. At a pressure of 20 psi the effective swath is 50 feet wide. We normally enter the right-of-way and drive until about one-half of the mixture in the tank is used or until some obstacle, such as a fence, crops, or a creek, has been encountered. The truck is then turned around, and the other side of the right-of-way is sprayed. The truck speed is 2 miles an hour, resulting in the spraying of 6 acres of brush an hour and the application of 50 gallons of mixture an acre.

Numerous test plots were established with the automatic spray nozzle using different chemicals at various rates. The best mixture for our region appears to be 2,4,5-T esters and water, applied at the rate of 50 gallons an acre, using 1-1/2 gallons, or 6 pounds, of acid.

In an effort to reduce right-of-way maintenance cost further and in order to keep pace with the growth of TVA's transmission system, a contract was negotiated with a helicopter contractor in July 1958 to spray 382 acres. A mixture of 1 gallon of 2,4,5-T esters, containing 4 pounds of acid, in 4 gallons of oil was applied at the rate of 5 gallons of mixture an acre. We were concerned about the volatility and drift of the oil; and, since all of this work was on an experimental basis, about 1/2 of this acreage was sprayed using only water as a carrier. One gallon of 2,4,5-T esters, containing 4 pounds of acid, was applied in 4 gallons of water an acre.

This spraying was done on rights-of-way in remote mountainous areas, where spraying by ground crews was almost impossible and the cost was prohibitive. The mixed species present were dense and ranged from 6 to 20 feet in height, with the majority averaging between 10 to 20 feet. The spraying was done late in the season; however, we felt that adequate moisture was in the soil for continued plant growth to aid in the chemical translocation. In the late summer, 2 months after application, the susceptible species were defoliated, or the leaves had turned brown. Chemical translocation was evident in the stems of tulip poplar, sweet gum, black gum, sumac, persimmon, and sassafras. We could see very little difference at this time between the results of the spraying with oil as a carrier and those in which water had been used.

In 1959, after one growing season, it was observed that good control was obtained on sweet gum, black gum, tulip poplar, black locust, wild cherry, sassafras, sumac, persimmon, and the majority of the oaks; that fair control was obtained on red oak, chestnut oak, redbud, and hickory; and that poor control was obtained on maple, elm, ash, sourwood, pine, and cedar. This inspection showed that the oil spray had a slight advantage over the water spray in controlling a few of the more resistant species.

During June and July 1959 a private contractor sprayed 4,750 acres of brush by helicoptor; in 1960 a contractor sprayed 6,944 acres, and 2,160 acres was sprayed by TVA using a Sikorsky S-55 helicopter. All methods and formulations of brush control seem to have some disadvantages, and helicopter application is no exception to this rule. The major disadvantage of helicopter application is the critical weather limitations. This type of spraying is much more sensitive to wind than ground application, and the work must be confined to a period when there is scarcely any wind. The helicopter spraying normally began at daybreak, weather permitting, and ceased when the wind velocity increased to 3 miles an hour. Spraying began again late in the afternoon, when the wind velocity decreased to 3 miles an hour, and continued until dark.

Damage claims arising from drift to adjacent property have not been a serious problem so far, but this is an inherent possibility in helicopter application and requires special consideration at all times.

One incentive to the use of helicopter in chemical application is the lower cost realized in areas where accessibility is difficult, such as mountains and swamps. Another incentive is the comparative speed, which enables the coverage of considerably greater acreage while the plants are more receptive to the herbicides.

We have been experimenting with the invert materials for several years; however, very little of this material has been applied to transmission line rights-of-way until recently. We have applied it by the basal and foliage methods, using the hand gun and the orchard blower. With these methods, however, our results were not promising. In 1959 a contractor, using a helicopter equipped with a whirling variable-speed disk that throws the chemical out, applied 1,000 gallons of invert material to a right-of-way for study and evaluation. It was applied at the rate of 2 gallons of esters, containing 2 pounds of 2,4,5-T acid a gallon, in 8 gallons of water, making a total of 10 gallons of material an acre.

In 1960 numerous test plots using various invert or thickened chemicals at different rates were established. This material was applied by a TVA Bell helicopter. Invert emulsions are viscous spray mixtures with a consistency like mayonnaise. These qualities result in a greater control over drift and permit the use of a helicopter with wind speeds up to approximately 10 miles an hour, allowing more flying time a day. Further studies with respect to percentage of kill and drift control will be needed to determine the full value of invert emulsions for right-of-way brush control.

In the beginning of our chemical brush control program all spraying was limited to the blanket foliage spray, which, of course, was limited to approximately 3 months during the year. It was soon realized that it would become necessary to respray in 2 to 5 years; therefore, our research program included work with esters and oil, using the basal method. The basal method was included in our program primarily as a re-treatment where the stem count was low, thus lifting the seasonal restrictions on spraying and virtually eliminating the possibility of crop damage, since the work was done during the dormant season. Since some species were resistant to the foliage spray and remained on the rights-of-way, this method was found to be effective on certain of these resistant species, such as maple, ash, conifers, and elm.

With the rapid construction of new lines it was realized that other methods were necessary to keep pace with the rapid growth of the transmission system, and extensive research was conducted in the stump-treatment method. This method, which is one of our most effective, was perfected and adopted as a part of our program in 1957 after 3 years of experimental work. It is used after the initial clearing of new rights-of-way.

We have also tried stump treatment on recleared rights-of-way, but the results have not been too satisfactory. One of the major problems is that the brush is not burned, and moving the brush to get to the stumps is an expensive operation. Also, the crew workers are unable to find many of the small stumps to spray them; therefore, considerable growth appears on these rebrushed rights-of-way the season following the treatment. Vines and briars make it difficult to remove the brush and to locate the small stumps.

At the present time a mixture of 3 percent of 2,4,5-T esters in diesel oil is used for the basal and the stump treatment methods. The number of gallons an acre is determined by the stem count. The root crown of the brush or the stump, including all the exposed roots, is thoroughly wet with the mixture. When conifers occur in the course of basal treatment, it is best to spray the entire plant.

In 1960 a portable mist blower was used on an experimental basis for applying concentrated mixtures of various chemicals, but we have not had sufficient time to evaluate the effectiveness of this method of application. This work will be continued, with evaluations of this method.

Extensive experimental work has been done with numerous soil sterilants to determine their possibilities in pole degrassing, which is done in fire hazard areas to eliminate grass and weeds and prevent poles from burning as a result of grass fires. Chemicals are applied in a 6-foot radius around the base of a pole, resulting in an area treated of approximately 100 square feet. Some of the chemicals have been very effective and appear to be more economical than the "scalping" method.

The control of danger trees outside the cleared rights-of-way presents an additional and expensive maintenance problem, which is also accomplished by both chemical and mechanical methods. Sometimes danger trees are cleared by mechanical methods; however, we have found that it is usually more economical to control them by the application of a 3-percent mixture of 2,4,5-T esters in diesel oil to an overlapping axe frill encircling the tree at a height not more than 12 inches above the ground line.

We have done research work with almost all chemicals for weed and brush control that have come to our attention, and many of them have been included in our program. The chemicals have been in liquid, powder, granular, and pellet form. We have used them in storage areas, transformer yards, riprap, and drainage ditches and along railroads to keep these areas clear of vegetation, in addition to transmission line rights-of-way.

Numerous chemicals have been used at various rates, and in some instances two or more chemicals are mixed in an effort to obtain the desired results at a cost believed to be economically feasible. We have used almost all known types of equipment, methods, and techniques for application of the various chemicals.

We believe that all of us who use herbicides have a definite responsibility to the general public to exercise extreme discretion when using these chemicals along rights-of-way that are conspicuously exposed to public view. This is particularly true in those areas where garden clubs, civic organizations, or government agencies have made special efforts to improve the landscape. The practice of self-discipline by users of these chemicals should result in their public acceptance and thereby reduce pressure for restrictive legislation.

So far, in the TVA area we have not experienced any particular resistance to the use of these herbicides. We have, of course, had frequent inquiries from various groups regarding the use of these chemicals. We have taken every opportunity to explain our long-range program to these groups, educating them in the controlled use of herbicides, the economics involved in this method of brush control, and the improvements on the right-of-way landscape following the temporary "brownout" stage. We believe that it is just good business to openly discuss this maintenance technique with the public in order that the chemical program will be presented in a favorable manner and the possibility of unfavorable criticism be minimized thereby.

<u>Summary</u>

We are convinced that mechanical clearing is not the answer to the over-all brush control problem in the Tennessee Valley region. The cost recurs periodically, every 1 to 4 years; and each clearing is as difficult as the previous one, if not more difficult.

A long-range chemical program, properly planned and with adequate supervision to completion, will gradually lengthen the cycle of costly brush control and abruptly reduce the resprouting potential of the brush. Today we know that chemical brush control is not a "one-shot cure-all" for the majority of our rights-of-way. Chemical brush control may be accomplished by several methods, from the ground as well as from the air, depending upon the specific problem. After the specific brush control problem has been determined, a successful right-of-way maintenance program at a reasonable cost will depend upon selecting the proper chemicals and equipment and making certain that the crews are thoroughly trained and adequately supervised in their proper use.

The perennial search by electric utilities throughout the nation for new cost-cutting procedures for brush control has rung up impressive savings through the development of cost-cutting methods. As a result of new equipment, methods, techniques, and chemicals during the past 2 years our production has increased 50 percent over fiscal year 1958, while our budget has been reduced 30 percent during the same period.

More progress has been made in brush control methods and techniques during the last decade than in the entire development period previously. Through continuing cooperation with chemical formulators, manufacturers, research groups, and other utility companies, we believe that even more progress can be made during the next decade so that further reductions in over-all maintenance costs can be realized.

A Progress Report on Urab* Brush Killer

R. L. Pierpont[1]

INTRODUCTION

During the last several years Urab has been tested for the control of brush on utility, highway and railroad right-of-ways in the United States and Canada. The purpose of this paper is to discuss the results obtained with granular, pellet, and oil or water emulsifiable liquid Urab formulations on numerous species of woody plants.

In brush control work, herbicides are generally used as broadcast or selective treatments. Over the years the broadcast technique has been most widely used; however, in recent years, due to the increased interest among wildlife agencies, conservation groups and progressive utility companies, the selective approach is gaining in favor. The commercially available formulations of Urab are applicable for use as either broadcast or selective treatments dependent upon its envisaged use.

FORMULATIONS & RESULTS

The rate of Urab required to control brush, and the length of time necessary for the herbicide to take effect depends upon the species, age, and growing stage of the brush to be controlled, soil type, soil moisture at the time of application, rainfall following application, type of formulation and method of application used. Urab 22% Granular or 25% pellets are generally used at rates of 80-120 lb/A broadcast evenly over the area to be treated, or as spot and basal applications of 1-2 oz per clump. The 3 lb/gal liquid concentrate formulation is used at rates of 6-9 gpa diluted in enough water or oil (kerosene, fuel oil, diesel oil or aromatic weed oil) to give good coverage. Approximately 75-150 gpa is needed, depending on the size and density of the brush. In spot or basal applications, 2-3 tablespoons (1-1½ fluid oz) of undiluted Urab Liquid Concentrate are used per clump, depending on the size of the clump, or the Urab Liquid Concentrate may be diluted at the rate of 1 qt/5 gal of water or oil and applied evenly to the base or root area of the plant at the rate of 1/2 to 1-1/2 pt per clump.

* Trade mark of Allied Chemical Corporation - 3-phenyl-1, 1-dimethylurea trichloroacetate (formerly GC-2603).

1) General Chemical Division, Allied Chemical Corp., New York, N.Y.

Some of the earlier work with Urab as a brush killer was conducted in Tennessee, Texas, North Carolina, and Florida. L. H. Prescott (1), TVA, Chattanooga, Tennessee, obtained satisfactory control of mixed brush consisting of oak, hickory, maple, sourwood, dogwood and shortleaf pine, using both the granular and oil or water miscible Urab formulations. The Urab 22% Granular was applied directly on the soil 6-12 in from the base of brush at rates of 2-6 oz per clump. The liquid concentrate was injected undiluted up to 6 in into the soil at the base of the brush with a Mack anti-weed Gun at rates of 20-60 cc per clump. It was also diluted to 3% actual Urab by volume with water or oil and applied as a basal spray. The basal method was most effective.

In an extensive screening program conducted by the Department of Range and Forestry of the Texas Agricultural Experiment Station (2) to evaluate the possible use of granular and pelletized herbicides for selective control of woody plants on range lands, Urab 22% Granular was one of several chemicals tested. Applications were made in the late Spring of 1959 on post and blackjack oaks, running live oak, water and willow oaks, persimmon and smilax at rates of 8.8 to 26.4 lb/A active ingredient. Good initial defoliation was noted from broadcast applications at rates of 8.8 to 17.6 lb/A on persimmon, running live oak and post oak growing on deep sandy soils. Application of 17.6 lb/A in strips 5 to 7 ft apart gave good topkill of post oak and running live oak. Smilax showed little response to the treatment.

During 1959 and 1960 Urab has been under test at various locations throughout the Northeastern United States and in the provinces of Ontario and Quebec in Canada. Urab has been successfully applied using hydraulic sprayers, mist blowers, knapsack sprayers, fertilizer spreaders and seeders, and by helicopters and fixed wing aircraft. Urab granular, pellet and liquid concentrate formulations have been applied, and the chemical appears to be particularly promising for the control of conifers, white and yellow birch, willow and oak infesting railway and utility right-of-ways.

In September, 1959, at Cookshire, Quebec, Urab Liquid Concentrate was applied as an overall foliage and bark coverage treatment at the rate of 2 gal/250 gal water/A to a stand of mixed brush consisting of white and yellow birch, red maple, conifers, willow and black cherry. The heighth of the trees varied from some less than 6 ft to trees 20-25 ft high. One year after the Urab was applied, all growth up to 6 ft high with the exception of red maple is dead. Cedars, spruce and black cherry 6-20 ft high, and most willow and birch are dead, and the remainder are 90% or more defoliated with only small distorted sucker leaf growth apparent. Control of red maple varies from complete kill of most of the smaller trees, to partial to complete defoliation and kill of the larger 20-25 ft high trees. Some of these maple trees with extensive root systems are dead, others exhibit light sucker re-growth and still other exhibit regrowth sufficient to indicate that the tree may completely recover.

Basal treatments at the same location with Urab Liquid Concentrate diluted 1-9 in water or oil applied in May, 1960, killed white birch, willow and black cherry. Variable results have been obtained on red maple, some trees up to 20-25 ft high are dead, while others exhibit distorted sucker leaf regrowth.

In the Toronto area a stand of basswood, oak, willow, black cherry, poplar, birch, ash and red maple was sprayed with Urox Liquid Concentrate at the rate of 4 gal/100 gal water as an overall foliage treatment to run-off in late June. In mid-August topgrowth was completely browned out on most species, but some resprouting was apparent on red maple.

In another test, Urab Liquid Concentrate 1 gal/120 gal water was applied as an overall foliage coverage treatment to run-off to mixed brush on a utility right-of-way near North Bay, Ontario during the last week in June. The growth consisted mainly of conifers and red maple. During the first three weeks after treatment little herbicidal effect was apparent; by the end of the 5th week conifers started to brown, and spotted browning of red maple leaves occurred. Six weeks after the treatments were applied the conifers were 95% browned out and the needles were dropping, red maple topgrowth was 50% browned out, and other mixed brush varied with topgrowth brownout ranging from 50-100 percent. Little or no injury to the grass and broadleaf weed undergrowth occurred.

Urab Liquid Concentrate at 1-1/3, 2 and 2-2/3 gal/10 gal oil and 2 gal in 10 gal water/A was successfully applied with a helicopter equipped with an apparatus that is used for applying invert emulsions by air. The test treatments were applied during early July to utility transmissions lines of the Ontario Hydro Electric Power Co. at Hagar, Ontario. Growth consisted primarily of conifers and low growing mixed brush. Six weeks after application all dosages of Urab were effectively browning out conifers, and causing the needles to drop. Other low growing brush, grass and broadleaf weed topgrowth brownout was also apparent. A definite spray pattern was apparent with the chemical confined to the right-of-way.

During 1960 a test was conducted on a railroad right-of-way in New Jersey. The brush consisted of red maple, wilow, poplar, locust, elm, white birch, oak, sassafras, bush honeysuckle, wild cherry, poison ivy and climbing rose. Urab Liquid Concentrate was applied in May as overall coverage foliage treatments to run-off at rates of 3-1/2, 5, and 7-1/2 gal in 100 gal of kerosene or water/A. The oil treatments browned out all topgrowth within 24-48 hours, but maximum brownout achieved by the water treatments did not occur until two to three weeks after the treatments were applied. Observations made throughout the season until late September show that 1) dosages of 5 and 7-1/2 gal/A of Urab Liquid Concentrate in either oil or water carriers appear to have effectively controlled wild cherry, white birch, poplar, oak, willow, sassafras and poison ivy; 2) red maple, locust, elm, bush honeysuckle and climbing rose, although initially 100 percent defoliated, now exhibit leaf regrowth. For the most part these leaves are small, undersized, and chlorotic with the amount of leaf growth present 10 to 30 percent of normal; 3) dosages of 3-1/2 gal/A of Urab Liquid Concentrate in both oil and water carriers appear to be as effective as the higher rates against the more susceptible wild cherry, birch, etc.; but this lower rate is not as effective as the higher rate against the hard to kill maple, locust and elm.

Tests have been conducted also with the Urab pellet formulations. In Canada dosages as low as 20 lb/A of 25% Urab pellets applied as broadcast treatments effectively browned out topgrowth and defoliated black cherry, white birch, maple, willow and conifers. Dosages as high as 80-100 lb/A of 25% Urab pellets applied as broadcast treatments were necessary to defoliate oaks in New Jersey. The pellets do not act as rapidly as the liquid Urab formulation, and results to date indicate the pellets are more effective when they are applied as spot treatments to clumps or individual trees.

Tests have also been conducted with Urab wherein it was combined with 2,4-D, 2,4,5-T, 2,4-D-2,4,5-T mixtures, Amitrol T, Kuron and Kuron 245. Quicker topgrowth brownout occurs with such combinations than when Urab Liquid Concentrate is applied alone in water.

SUMMARY

Field tests conducted during the past several years show that Urab applied as a dry granular or pelleted product containing 22 or 25% active ingredient, or as an oil soluble or water emulsifiable 3 lb/gal liquid concentrate effectively control brush.

White and yellow birch, sassafras, staghorn sumac, wild cherry, oaks, willow, poplar and sassafras are among the more susceptible woody species, but promising results have been obtained on red maple, conifers, locust, elm, poison ivy and briars.

The liquid concentrate appears to be the most effective when applied as an overall foliage coverage or basal treatment, and the granular and pellet formulations are effective when applied as spot or broadcast treatments.

Urab is an effective chemical for control of brush on utility, highway, and railroad right-of-ways, particularly where regrowth of grass cover is desired. Both soil and foliar applications are effective and the results obtained vary with the dosage used, species of brush, soil type, weather conditions and type of application.

Urab has been successfully applied with hydraulic sprayers, mist blowers, knapsack sprayers, fertilizer spreaders and seeders, and by helicopters and fixed wing aircraft.

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THE APPLICATION OF THE TRIAZINE HERBICIDES FOR INDUSTRIAL WEED CONTROL

By

Leo Miles [1]

INTRODUCTION

The purpose of this paper is to pass on information based on broad practical field experience, as to how the triazine herbicides, Simazine and Atrazine, can be most effectively and economically used for the control of weeds on industrial sites, alone or in combination with other herbicides. Weed problems on industrial sites are in some cases difficult to control because of complicating factors found in the soil, as well as the survival and further propagation of difficult-to-control species brought about by previous herbicide treatments. It is in these types of situations a careful appraisal of the weed problem is necessary in order to use the correct herbicide or a combination of herbicides to control the weed problem.

APPLICATION OF SIMAZINE TO INDUSTRIAL WEED PROBLEMS

Simazine is a soil sterilant type herbicide of relatively low water solubility, with long residual action recommended primarily for pre-emergence application. For best results, fall or early spring applications are recommended. Simazine is effective in controlling a wide range of non-woody annual and perennial broadleaf weeds and grasses at dosage rates ranging from 10 - 30 lbs. per acre. Simazine has been applied adjacent to shrubs and trees by highway departments with no reported injury to these woody plant species. Simazine applied to soil has very little lateral movement providing the soil it was applied to has not been moved. Simazine has in general been successfully applied to sloping ground and fence lines running parallel to sloping ground with little or no runoff problem.

APPLICATION OF ATRAZINE TO INDUSTRIAL WEED PROBLEMS

Atrazine is recommended for pre or early post-emergence

1 - Geigy Agricultural Chemicals, Ardsley, New York

application. Atrazine has a water solubility of 70 ppm, compared to Simazine which has a water solubility of 5 ppm. The herbicidal action of Atrazine is considerably faster than Simazine. Unlike Simazine, Atrazine will burn foliage. Its basic mode of herbicidal action is primarily by absorption through the plant's root system. Atrazine is effective in controlling a wide range of annual and perennial broadleaf weeds and grasses at dosage rates ranging from 10 - 20 lbs. per acre. When runoff or lateral leaching is undesirable such as on slopes or adjacent to desirable trees and shrubs, Atrazine is not recommended. Simazine is the preferred herbicide for this type of situation.

THE USE OF THE TRIAZINE HERBICIDES IN COMBINATION WITH OTHER HERBICIDES

The primary reason for using combinations of Atrazine or Simazine with other herbicides is to effectively and economically control weed species not controlled by the triazine herbicides alone. Conversely, it may be stated that the addition of Simazine or Atrazine to systemic, hormone or "knockdown" type herbicides will increase the herbicidal effectiveness of these materials by providing residual action, particularly after the systemic, hormone or knockdown herbicides have lost their effectiveness. Where the practice of later post-emergence application of herbicides is followed, especially where a large variety of woody and non-woody plants are present in the population, a combination of Atrazine with other types of herbicides provides excellent weed control.

In certain instances where difficult-to-control plant species are present in the weed population, additional applications of a specific herbicide or combination of herbicides will be necessary to control the problem species.

Simazine or Atrazine, when used in combination with one or two of the following herbicides, has given excellent weed control when applied post-emergence:

1. Radapon
2. Aminotriazole
3. Sodium chlorate formulations
4. Sodium Arsenite
5. Pentachlorophenol formulations
6. 2,4 D
7. 2,4 5 T
8. TCA
9. Kuron

The dosage rate of the systemic, hormone or knockdown herbicide generally follows the label recommendations of the manufacturer or formulator. In many cases, an on-the-scene assessment of the weed problem is made and dosage rates of an appropriate herbicide made accordingly. Atrazine or Simazine was used in the various combinations at rates of 5 - 10 lbs. per acre. The amount of Atrazine or Simazine in the combination is determined by the weed problem, time of application and rainfall distribution.

LOW WATER GALLONAGE APPLICATION OF ATRAZINE

Atrazine 80W has been successfully applied to railroad yard and branch line trackage at the rate of 12½ lbs. per acre. The Atrazine 80W was applied at a concentration of one pound of Atrazine 80W to one gallon of water, making a total of 12½ gallons of water to apply 12½ lbs. of Atrazine 80W (10 lbs. active) per acre. The Atrazine 80W was easily maintained in suspension with a recirculation pump. Successful weed control for a full season was achieved from a 10 lb. per acre application of Atrazine applied early post-emergence to a mixture of annual and perennial broadleaf weeds and grasses. When water is at a premium or when it is desirable to make spray equipment cover more acreage with less water, Atrazine 80W lends itself to this type of application.

COMPARISON OF TECHNIQUES AND SPECIFIC HERBICIDES FOR THE CONTROL OF BLACK LOCUST, SASSAFRAS, AND SUMAC. 1/

John P. Sterrett and W. E. Chappell 2/
Virginia Agricultural Experiment Station
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The control of black locust, sassafras, and sumac has been one of the major problems in brush control. These trees are especially difficult to kill because they not only sprout from the root crown but have the added ability to produce suckers from underground parts as well.

The objective of this investigation was to evaluate the effectiveness of specific herbicides and several methods of application on black locust, sassafras, and sumac, and to compare the control of these woody plants with that of associated species.

Procedure

The experiments were conducted in the field with chemicals and concentrations that had shown promise in previous field studies (tables 1 & 2). The plots were located on the west slopes of utility rights-of-way at an elevation of approximately 2,000 feet near Blacksburg, Virginia. The chemical mixtures were applied with a 7-gallon per minute pump at a pressure of 200 psi for dormant season oil mixtures and 400 psi for growing season water mixtures. A trigger gun with a #6 tip was used for both mixtures. Each chemical was applied in twenty-five gallons of oil as a carrier during the dormant season and in fifty gallons of water as a carrier during the growing season. The growing season applications were made in July, 1959 and the dormant season applications in January and April, 1960. Brush density and height determined the plot size. The plots were replicated from three to four times and each plot was divided into four equal parts to determine stem uniformity. All stems were counted immediately after treatment and again at the end of the following growing season. The second count was made in September, 1960. Original stems were considered dead only if they were killed to the ground line. Regrowth from the root crown or underground parts was counted and designated resprouts.

1/ These studies were supported in part by research grants from the Appalachian Power Company, The F. A. Bartlett Tree Expert Company, The Amchem Products, Inc., the Diamond Alkali Company, The Dow Chemical Company, and The E. I. DuPont de Nemours & Company.

2/ Graduate Research Assistant and Professor of Plant Physiology.

The following methods of application were used.

<u>Stem broadcast</u> - All stems and branches were sprayed with special emphasis placed on the root crown.

<u>Stem broadcast and soil</u> - All stems and branches were sprayed with special emphasis placed on the root crown and a three foot radius of soil around each clump or stem of black locust, sassafras, and sumac. Other species did not receive soil treatments.

<u>Broadcast basal and soil</u> - The lower one third of each main stem was sprayed from, and including, the root crown up and a three foot radius of soil around each clump or stem of black locust, sassafras, and sumac. Other species did not receive soil treatments.

The density of the brush averaged 7,000 stems per acre, and the average height was 12 feet. Gallons per acre for the three methods of application averaged as follows:

<u>Stem broadcast</u>

Summer - 550 gallons of water per acre.

Dormant - 230 gallons of No. 2 fuel oil per acre.

<u>Stem broadcast and soil</u>

Dormant - 300 gallons of No. 2 fuel oil per acre.

<u>Broadcast basal and oil</u>

Dormant - 250 gallons of No. 2 fuel oil per acre.

The chemicals used in summer treatments were: triethanol amine salts of 2,4-D and 2,4,5-T, liquid amitrol and the triethanol amine salt of 236-trichlorobenzoic acid. In the dormant treatments the 2-ethylhexyl esters of 2,4-D and 2,4,5-T was used.

Table 1 - Results of chemicals applied in July, 1959, by the stem broadcast method, which show the percentage of resprouting and survival of original stems of black locust, sassafras and sumac as compared with the percentage of resprouting and survival of original stems of other species

Method of application and amount of chemicals per 100 gallons of water	BL.S.&S. 1/		Others 2/		All Species
	% Resprouting	% Orig. stems alive	% Resprouting	% Orig. stems alive	% Resprouting & orig. stems alive
Stem Broadcast 3/					
Amine T 4 lb.	66	9	20	17 a	51
Amine D&T 4 lb.	68	6	21	22 a	61
236 TBA 4 lb. + ATA 1 lb.	30	1	12	47 b	47
236 TBA 2 lb. + ATA 2 lb.	21	2	19	47 b*	51
Method Average (%)	51	6	18	33	53
Check (cut)	141	0	141	0	141

* Figures in a vertical column followed by a different letter are significantly different.

1/ Composed of black locust, sassafras, and sumac.

2/ Composed of red oaks, white oaks, maples, hickory, ash, cherry, black gum, sourwood, poplar, and other species in lesser amounts.

3/ Explained in the text.

Table 2 - Results of chemicals applied in January and April, 1960, by three different methods at the concentration of 6 pounds to 100 gallons of oil, which show the percentage of resprouting and survival of original stems of black locust, sassafras and sumac as compared with the percentage of resprouting and survival of original stems of other species

Methods of application and amount of chemicals per 100 gallons of oil	JANUARY, 1960 % Orig. stems alive	JANUARY, 1960 % Resprouting 1/ BL.S.&S.	JANUARY, 1960 % Resprouting 2/ Others	JANUARY, 1960 % Resprouting BL.S.&S. + Others	APRIL, 1960 % Orig. stems alive	APRIL, 1960 % Resprouting 1/ BL.S.&S.	APRIL, 1960 % Resprouting 2/ Others	APRIL, 1960 % Resprouting BL.S.&S. + Others
Stem broadcast 3/								
Technical T 6 lb.	.7	174	23	61	.04	179	19	91
Formulated T "	.7	233	35	94	.2	153	11	67
Technical D&T "	.7	180	35	94	.4	149	14	62
Formulated D&T "	.4	185	48	110	.05	152	22	65
Method average (%)	.7	194	34	89	.2	157a	16	68a
Stem broadcast & soil 3/								
Technical T 6 lb.	.2	127	30	65	0	144	9	66
Formulated T "	.2	143	24	68	0	144	10	64
Technical D&T "	.4	224	40	96	0	146	21	71
Formulated D&T "	.2	162	32	51	.2	163	14	71
Method average (%)	.2	163	32	69	.1	149a	13	68a
Broadcast basal & soil 3/								
Technical T 6 lb.	.4	138	21	49	.6	79	8	36
Formulated T "	.9	143	35	56	.4	73	6	40
Technical D&T "	.6	178	33	64	.3	83	7	41
Formulated D&T "	.6	187	48	70	.6	129	9	75
Method average (%)	.6	159	34	60	.4	91 b*	8	48 b*
Check (cut)	0	176	213	209	0	323	255	294

* Figures in a vertical column followed by a different letter are significantly different.

1/ Composed of black locust, sassafras, and sumac.

2/ Composed of red oaks, white oaks, maples, etc.

3/ Explained in the text.

Results and Discussion

Data from both the growing and dormant seasons' experiments were analyzed by the analysis of variance method. Even though the sites and density within plots were selected as uniformly as possible, variance still occurred among replications. Most of this variance could be attributed to the variety of species involved (tables 1 & 2). Under these conditions only trends could be recognized.

An analysis of the data from the July experiment (table 1) showed that significant differences occurred in the percentage of original stems alive of the oaks, maples, hickories, etc. (other species). The amines killed 27 percent more of the original stems than the TBA and ATA combinations. There was a definite trend, although not significant, which showed that TBA and ATA combinations controlled the resprouting of black locust, sassafras, and sumac (BL.S.&S. group) better than the amines. There was no significant difference between chemicals when all of the species were combined.

Data from the dormant treatments in January (table 2) showed no statistically significant difference between chemicals or methods. However, there was a strong trend favoring the soil applications when both groups of woody plants were combined. The percentage of resprouting for both technical and formulated 2,4,5-T was slightly lower than 2,4-D + 2,4,5-T on other species, but not significantly different at the 5% level. The percentage of resprouting in the BL.S.&S. group for all three methods of applications was very high. Less than one percent of the original stems in January survived in the two groups of species (table 2).

Dormant treatments in April (table 2) showed a statistically significant difference between the methods of application but not between chemicals. The broadcast basal and soil method on the BL.S.&S. group showed 58 percent less resprouting than the stem broadcast and soil method and 66 percent less resprouting than the stem broadcast method. Similar differences were significant at the 1% level with the BL.S.&S. and other groups combined. Less than one percent of the original stems survived treatment for both groups of brush in April.

Significance appeared at the 1% level between January and April tests in the other species indicating less overall resprouting in the April than in the January treatments. There was also a strong trend which showed a lower percentage of resprouting in the BL.S.&S. group with the broadcast basal and soil method in April than in January. In both January and April applications there were no significant differences between 2,4-D + 2,4,5-T and 2,4,5-T alone at the 5% level on black locust, sassafras, and sumac.

Summary

The percentage of resprouting of black locust, sassafras, and sumac was lower for July applications than for the best dormant season applications.

However, there was a much lower percentage of original stems of all species alive as a result of the dormant tests than for the July test. TBA and ATA combinations were only about 50 percent effective in killing the original stems of other species.

Soil applications were more effective in April than in January. Possible explanations for this are (1) the roots of the BL.S.&S. group were more actively growing in April than in January and (2) 2,4-D and 2,4,5-T could have been broken down in the soil in the January experiment before the roots were active enough to be affected.

There was no statistically significant difference between dormant applications of 2,4-D + 2,4,5-T and 2,4,5-T alone on the BL.S.&S. group. Both technical and formulated 2,4,5-T exhibited a slightly lower percentage of resprouting on other species than did 2,4-D + 2,4,5-T but the difference was not statistically significant.

The dormant broadcast basal and soil method of application was equal to or better than the overall dormant methods of application for all species. A possible explanation is that the unsprayed terminal buds of the trees in the basal treated method facilitated the movement of the herbicides into vital parts of the trees.

Some advantages of the dormant broadcast basal and soil method of application are:

(1) Less chemical is required for the control of woody plants, such as the oaks and maples, that do not exhibit the ability to sucker from underground parts.

(2) Tall brush can be sprayed more easily.

(3) Oil applications are much easier on the spray operators since the spray guns are seldom pointed upward thereby reducing spray drift.

These results show definite trends, but in order to be more conclusive resprouting counts should be made again after the second growing season.

THE CONNECTICUT ARBORETUM RIGHT-OF-WAY DEMONSTRATION AREA-- ITS ROLE IN COMMERCIAL APPLICATION.

William A. Niering[1]

Introduction

With the introduction of herbicides, a new technique has become available in the management of vegetation on rights-of-way. It was in the light of this development that the Right-of-way Demonstration Area was set up in 1953 on a 1500' sector of a utility easement that crosses the Arboretum. Since its establishment the vegetation has been manipulated with various chemical techniques with the objective of creating a vegetational pattern of greatest stability and highest conservation values, while at the same time meeting the clearance requirements of the utility. It was anticipated that such a demonstration, exhibiting sound management, would be of interest to those concerned with this problem on rights-of-way. Since the initial progress report (1) further treatments have been made and the management principles advocated have been employed commercially on the remainder of the line. The purpose of this paper is to evaluate the various techniques and to point out the feasibility and desirability of sound vegetation management. The author wishes to acknowledge the following companies for supplying chemicals and equipment: Amchem Products Inc., American Cyanamid Co., Diamond Alkali Co., Dow Chemical Co., E.I. du Pont de Nemours & Co., and D.B. Smith & Co., Inc. Appreciation is also due the Connecticut Light & Power Co. with whose cooperation the project was initially established, and the Hartford Electric Light Co. which presently owns the right-of-way. Acknowledgments are also due Mr. Oscar F. Warner and the Walgren Tree Experts Inc. for their assistance in spraying plots using commercial equipment.

Program of Vegetation Management

The primary aim in management should be to eliminate only the undesirable vegetation that would either impede access or eventually grow or fall into the lines. As much of the existing shrub vegetation should be preserved as possible, not only for its high wildlife value (2,3,4), but also in order to create a ground cover which will minimize invasion and establishment of new tree growth in the future. The role of shrub cover in preventing tree establishment is documented in the literature (5,6) and further evidence has been observed on the demonstration area. This selective approach tends to minimize initial clearance costs in that only the unwanted growth is treated and also reduces future maintenance in that the preserved shrub cover will serve to prevent new tree invasion.

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The management procedures recommended are based on sound ecological principles as revealed by the published literature (7,8,9) and are in actual commercial practice by the more progressive utilities and State Forestry Departments (10,11). In the communities represented, three slightly different management procedures are required to produce a desirable vegetation pattern.

(1) Central part of right-of-way, directly under the wires. All tall-growing trees which might eventually grow or fall into the lines are removed. Low-growing shrubs and scattered taller shrubs are preserved. In general, shrubs that eventually grow over 3' in height should be removed if they occur in large colonies which spread over the ground for distances of 25' or more. A trail 8-10' in width, preferably composed of grasses, should be maintained in order to permit access for inspection and repair. A similar pattern is recommended around the bases of poles and towers.

(2) The sides of the right-of-way, between the outermost wires and the forest edge. Tall-growing trees which might eventually grow or fall into the lines are removed. Therefore, along the sides all shrubs and low-growing trees are preserved to form the densest possible cover so as to resist future invasion by trees.

(3) Forest edge adjacent to the right-of-way. Here tall-growing trees are removed before they reach the height of the wires. This eliminates the danger of trees falling into the wires and avoids costly cutting operations in the future.

The pattern created is a V or valley-like effect in which only low vegetation persists in the center of the right-of-way with taller growth along the edges on both sides.

Nature of the Vegetation

When established in 1953, two distinct cover types--shrubland and sprout-hardwoods--were recognized. The former, covering one-third of the line, was dominated by dense thickets of greenbrier and sawbrier (*Smilax rotundifolia*, *S. glauca*) and sumac (*Rhus copallina*) interspersed with other shrubs and tree growth. The more common trees included red maple (*Acer rubrum*) and black cherry (*Prunus serotina*). Herbaceous cover was limited to occasional openings. In the sprout-hardwoods type an upland and lowland phase was recognized. In the former, various oaks--white, scarlet, red and black (*Quercus alba*, *Q. coccinea*, *Q. rubra*, *Q. velutina*) along with black birch (*Betula lenta*) were dominant, while in the wetter areas, red maple was most common. Other trees on the line included hickory (*Carya* spp.), aspen (*Populus* spp.), gray birch (*Betula populifolia*), tulip (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*), white ash (*Fraxinus americana*). In some areas shrub growth was scattered; in other sections it formed continuous cover.

In surveying the easement, over forty species of desirable shrubs and low-growing trees were found. Among those shrubs most frequently encountered, which do not grow over 3' in height and are permissible whenever they occur on the right-of-way, are sweet fern (*Comptonia peregrina*), sheep laurel

(Kalmia angustifolia), huckleberry (Gaylussacia baccata), low bush blueberry (Vaccinium vacillans), Japanese honeysuckle (Lonicera japonica), and maple-leafed viburnum (Viburnum acerifolium). Those most commonly encountered which grow over 4' high are high bush blueberry (Vaccinium corymbosum and V. atrococcum), bayberry (Myrica pensylvanica), winterberry (Ilex verticillata), sweet pepperbush (Clethra alnifolia), mountain laurel (Kalmia latifolia), Virburnums (Viburnum spp.), alder (Alnus rugosa), flowering dogwood (Cornus florida), swamp azalia (Rhododendron viscosum), pinkster flower (Rhododendron nudiflorium), spiabush (Lindera benzoin), barberry (Berberis vulgaris), witchhazel (Hamamelis virginiana). These species are most desirable and permissible along the edge of the right-of-way. However, some utilities will also permit these species to persist directly under the lines if scattered in occurrence. The abundance of greenbrier and its tendency to crowd out other more desirable species and form impenetrable thickets is a local problem in this part of Connecticut and requires some modification in the management procedures as will be pointed out later. In 1954 the tree growth was cut and allowed to resurge for subsequent treatments.

Evaluation of Spray Techniques

Since 1953 over 40 plots 50' x 50' or larger have been established under or along the lines. Here various techniques have been employed using knapsack sprayers as well as commercial power equipment. In order to achieve the management objectives outlined, the spraying has been done selectively except for special plots where the aim was to determine the effect of indiscriminate applications. The various techniques employed include the basal, root-collar, dormant stem, stem-foliage, notching, frilling, and stump treatments. Some of the formulations and seasons of applications along with comments on effectiveness are given in Table I.

Although the basal technique gave effective root-kill in all seasons, root-collar applications were even more effective, as has been reported by other investigators (12,13). Trees up to 3" in diameter were root-killed using the root-collar technique which involved thoroughly wetting the soil around the root-collar. One very definite advantage of this method over the basal technique is that the chemical is specifically directed to the root-collar area. Therefore, the problem of accumulated leaf-litter around the stems preventing run-down to the root-collar is eliminated. For root-suckering species mid to late summer applications were most effective. When concentrations were reduced to 1:30, white oak showed some resistance with only 35%% root-kill.

Both of these techniques have been extensively used on the demonstration area and are highly recommended for right-of-way maintenance. Along with obtaining effective root-kill they can be applied very selectively, thus enabling one to preserve desirable shrubs and maintain a tight ground cover wherever it exists. Similar findings have been reported on the Penelec right-of-way in central Pennsylvania (14).

The dormant stem technique was employed on greenbrier as well as tree sprouts. Although formulations in oil are known to be effective,little work has been done with oil-water and water carriers. Data indicate that effective root-kill results when relatively high concentrations (1:20) are applied in water (Table I). By eliminating oil less damage results to desirable species. It has been found that this technique is especially adaptable to situations

TABLE I

Technique	Formulation	Season	Nature of vegetation and effectiveness
Basal	D&T, T:oil **1:20, 1:30	Jan. '55 Feb. '54 Mar. '56 July '55 Dec. '54	Excellent root-kill on most tree species (black oak 99%, black birch 98%, white oak 53%). Summer applications most effective on root-suckering species such as aspen and sumac.
Root-collar	T:oil 1:20	Feb. '55, '56 Aug. '55	Most effective technique employed. Excellent root-kill on oak, cherry, maple, birch and hickory any season; aspen in summer. Growth 6' to 3"DBH
Dormant Stem	D&T+oil 1:20	Feb. '55	Greenbrier (continuous 3-5'). Over 95% root-kill.
	T-$\frac{1}{2}$ oil $\frac{1}{2}$ water 1:20	Dec. '55	Excellent root-kill of black oak, gray birch, hickory, tulip, black birch.
	T+water 1:20	Mar. '60	Excellent control of red maple, black birch, hickory, yellow birch, black oak, 4-10'. Presumed root-killed.
Stem-Foliar	D&T-water 1:100 Commercial	Sept. '54	Good root-kill of black oak, black birch and aspen, averaging 87% root-kill. White oak very resistant; only 13% root-kill.
	D&T 1 gal. oil 3 gal. water 1:20	July '55	Over 95% root-kill of greenbrier. Most effective stem-foliar treatment.

** 1:20 equivalent to 5 gallons or 20 pounds acid equivalent of chemical per 100 gallons oil.

TABLE I (cont'd.)

Technique	Formulation	Season	Nature of vegetation and effectiveness
Stem-Foliar (cont'd.)	T-water 1:100 Commercial	June '59	Stem-kill of red maple--cherry resurge. Greenbrier and sumac vigorously resurging. Too recent to fully evaluate.
	Ammate 60 lbs. per 100 gals. water Commercial	June '59	Stem-kill of sweet birch, oak and hickory show some resistance. Too recent to fully evaluate.
Notching	Ammate 2 notches 1 tsp. per notch	Jan. '55	Black birch 2-3" DBH root-killed. Larger trees resistant.
Frilling	T-oil 1:30	March '59	Root-kill on red oak, aspen, black birch, and red maple 4-8"DBH.
Stump	D&T-oil T-oil 1:20	July '56	Excellent root-kill on stumps up to 3"-4".

TABLE I--Selected list of spray techniques employed on right-of-way demonstration area. Formulations, seasons of application and effectiveness on species treated are enumerated. 2,4-D-2,4,5-T and 2,4,5-T esters are referred to as D&T and T in appropriate carrier fuel oil, water or combination. A concentration of 1:20; one part chemical to twenty parts carrier is equivalent to 5 gallons or 20 pounds and equivalent of chemical per 100 gallons of carrier.

Stem-foliar sprays were applied by commercial power equipment, others by knapsack sprayers.

where dense growths, such as greenbrier, present a problem. With trained applicators a fair degree of selectivity is possible and desirable species can be preserved.

Stem-foliage sprays have been applied indiscriminately as well as selectively. Indiscriminate applications in September 1954 resulted in a 53% root-kill. Three out of the four tree species present were effectively root-killed. However, white oak was very resistant (Table I). Greenbrier was stem-killed but has presently resurged to its original density. Desirable shrubs such as mountain laurel, bayberry and high bush blueberry were root-killed. This points out the undesirability of using indiscriminate sprays. The 1959 commercial treatments are too recent to fully evaluate. However, certain trends are evident. The T-esters appear more effective than Ammate on most species but especially on root-suckering forms. Sumac and greenbrier are resurging considerably in the Ammate-treated areas. Of the tree species present, black birch is most sensitive to the T-esters and red maple to Ammate. Oaks and hickories appear most resistant. By doubling the concentration of T-esters, applications to wet stems and foliage appear effective.

In controlling greenbrier an oil-water formulation with a high concentration of T-esters (1:20) resulted in over 95% root-kill. Numerous other trials using water as a carrier gave good stem-kill but resulted in vigorous resurge.

Widespread use of the stem-foliar technique in right-of-way vegetation management should be carefully scrutinized. Data indicate that percent root-kill is less than with other techniques. Preservation of desirable shrub cover is also more difficult unless the personnel are carefully supervised. Indiscriminate applications should be avoided since desirable species are destroyed, as indicated in this study. In addition, unsightly brown-outs result. Only when other more effective and selective techniques are not feasible, are stem-foliar sprays recommended. On the demonstration area, the greenbrier cover directly under the lines represents a cover type where this technique is most applicable.

The stump treatment has been employed where trees were too tall to permit them standing under the wires. Therefore, cutting and immediate treatment of the stumps with 1:20 T or D&T in fuel oil has been most effective. Preliminary trials with amino triazole in water have resulted in a certain degree of root-kill during the summer. The addition of a dye to the spray increases efficiency.

Along the margins of the right-of-way in the forest edge, trees which have not yet reached the height of the wires are being treated and left standing. Here notching or frilling has been employed. Ammate in notches has been effective on black birch 2-3" in diameter but ineffective on larger trees. Best results have been with frills using 1:30 T-esters in oil. Trees up to 4-8" in diameter have been root-killed.

Problem of Species Susceptibility

It has already been pointed out that those techniques which tend to get an adequate concentration of the chemical on the stems and leaves or into the root-collar area give most effective root-kill. During the investigation, possible factors accounting for the differential effectiveness and species resistance to stem-foliar applications have become evident. Since stem-foliar applications are more effective than just foliage coverage it would appear that absorption probably occurs through both the leaves and bark. As noted by Leonard and Crafts (15) most effective absorption by the leaves can be anticipated during the early summer prior to maximum cuticle development. Four species which exhibit a relatively thick cuticle even early in the season include oak, hickory, cherry and greenbrier. These species also show a considerable resistance to stem-foliar sprays. In contrast, black birch with a thinner cuticle is most susceptible. Another possible deterent is the bloom or glaucous covering on the leaves and twigs of certain species which tends to resist wetting. Two species are of especial interest--white oak and sawbrier, both of which possess this characteristic and are extremely resistant. The texture of the bark as related to its ability to be wetted may also be of importance. Young sprout growth of white ash and white oak all have smooth stem surfaces. This may in part account for the resistant nature of these species.

In basal applications it was also noted that white oak showed some resistance. Here too, the stem texture may be important in that good root-kill was obtained when the chemical was applied to the root-collar area. From field evidence it would appear that better penetration of the chemical occurs on stem bases with a roughened bark texture.

Root-suckering species such as sassafras and aspen frequently resurge profusely following stem-foliar treatment. However, late summer applications resulted in good root-kill of small aspen less than 6' high, but greatly stimulated resurge of sumac. Mid to late summer basal or root-collar treatments have been effective on aspen as well as sumac. Susceptibility during the summer may be correlated with active downward movement of the chemical in the phloem at this time, especially into the highly complex clonal root system of these species.

In summary, the critical factor for getting root-kill is application of adequate chemical around the root-collar region as in the basal or root-collar techniques. Breaking the bark surface to assure penetration greatly increases effectiveness, as in the notch and frill techniques. In stem-foliage applications, thorough coverage of bark and stems is essential. However, total root-kill is less than with the other techniques in that certain species are more resistant than others.

Present Vegetational Pattern: Its Stability and Conservation Values

The present vegetational pattern on much of the demonstration area is essentially devoid of tall-growing trees. This infers that various shrub communities predominate, depending upon their former abundance. In the shrub community originally dominated by scattered tree sprouts, continuous shrub borders occur on both sides of the line with scattered shrubby areas directly under the wires. Herbaceous cover of grasses and goldenrods has increased, especially where greenbrier has been removed.

In the sprout hardwoods cover type the tree sprouts have been removed leaving continuous shrub borders of sweet pepper bush, mountain laurel and other species along the sides of the lines and scattered shrubs such as blueberry in the central strip. In the wetter areas, high bush blueberry, winterberry, arrowwood (*Viburnum dentatum*), and other valuable wildlife species are common. Also being maintained is a foot trail 8-10' wide directly under the lines. It should be pointed out that although a favorable pattern has been created in this area, the local abundance of greenbrier has modified the pattern, especially under the wires. On many rights-of-way low-growing species such as low bush blueberry, sweet fern and huckleberry are more common and, therefore, provide an even more desirable cover.

The stability or vulnerability of this vegetational pattern to invasion by new tree growth is of considerable importance from a management view point. In the dense shrub borders, where original tree growth has been removed selectively, establishment of new tree growth does not appear evident after seven years, which indicates a relatively stable shrub community. In contrast, tree invasion is rapidly occurring on a limited section of the right-of-way where the ground cover was reduced by stem-foliage applications. Here saplings of sweet birch 2-4' in height are common. indicating that reduction in ground cover, especially shrub growth, tends to favor invasion of new tree growth. From the standpoint of stability this further documents the value of preserving the existing shrub cover wherever possible.

The many conservation values derived from this approach are worthy of comment. The shrub cover preserved as a result of this technique provides the typical edge effect advocated by those interested in wildlife and game population. To those interested in flowering herbs and rare plants rights-of-way exhibit many of these species. In addition, landscape and aesthetic values are also of general public concern since these rights-of-way are seen from the road, especially those paralleling the highways.

<u>Management Principles in Commercial Application</u>

As previously mentioned, the management program recommended and used on the demonstration area is used in commercial practice by the more progressive utilities both on their cross-country rights-of-way as well as on those along roadsides.

Within the past few years, the principles employed on the demonstration area have been applied commercially on the contiguous three-mile section of the right-of-way. Two treatments, both selective, have been applied. In the winter of 1957 undesirable tall tree growth was cut and stump treated. In June 1959 a stem-foliar application was applied primarily to the greenbrier directly under the lines and to scattered tree sprouts still persisting. A most desirable shrub community has been created, especially along the sides of the right-of-way. Here over forty species of shrubs and low-grlowing trees have been preserved. In certain sections along the central strip shrub cover of mountain laurel, huckleberry, high bush blueberry, maple leafed viburnum and sweet fern is also common.

On the basis of present observations, only spot treatments will be needed in the future. A more complete report of this operation will be forthcoming when the final results of the 1959 spraying can be more precisely evaluated.

It is of significance that within the past five years there has been a trend toward more selective applications by certain utilities and spray contractors. Public pressure has played some role, especially along roadsides where the principles are also applicable (16). More progressive State Highway Departments employ only selective techniques in the removal of undesirable woody growth along roadsides. Recently special attention has also been given town roadsides in Connecticut. This has led to the formulation of sound spray techniques to be employed by all agencies involved in town roadside management (17). Although much progress has been made in creating an awareness of the need for good vegetation management, many sections of the northeast and especially the midwest have still to recognize and employ ecologically sound techniques.

SUMMARY

1) On a 1500' easement crossing the Connecticut Arboretum a right-of-way demonstration area has been established exhibiting sound vegetation management principles.

2) A selective approach is recommended involving the removal of only undesirable vegetation, thereby preserving low shrub and herbaceous cover directly under the lines and taller shrubs and low-growing trees along both sides.

3) Over forty spray plots have been established using various techniques and employing knapsack as well as commercial power sprayers.

4) The basal, root collar, and stump techniques result in the most effective root-kill and are most selective. These are highly recommended for use in right-of-way management.

5) Stem-foliar applications result in a higher percentage of resurge especially when more resistant species are present. It is also the least selective of techniques employed. This technique should be used only where other more selective treatments are not feasible.

6) Possible factors relating to species susceptibility are discussed.

7) Along with the many conservation values derived from this selective approach, the shrub borders preserved appear relatively stable with no apparent tree invasion after seven years. In contrast, tree invasion is conspicuous where shrub cover has been reduced.

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RECOMMENDATIONS FOR THE USE OF HERBICIDES [1] IN CONTROLLING UNDESIRABLE VEGETATION ALONG TOWN ROADSIDES IN CONNECTICUT

Mrs. Woolsey S. Conover [2]

General Recommendations

Undesirable vegetation, primarily tree growth, poison-ivy, etc., should be removed along roadsides whenever it creates a safety or health hazard, or whenever removal is necessary for the maintenance of utility lines. Along straight stretches of town roads where there are no utility lines a narrow mowed strip on either side of the road is necessary for the safety of pedestrians and motorists. Beyond this mowed strip, desirable shrubs and low growing trees should be preserved. On curves and where there are utility lines present, removal of trees and tall shrub growth is necessary for a considerably greater distance back from the travelled portion of the road. Low growing shrubs that will not interfere with sight line or utility installation, should be allowed to remain

Herbicides can assist greatly in the economic control of undesirable vegetation. In many instances they can be used by maintenance crews in conjunction with other work. The type of chemical treatment depends to some extent upon the existing problem. Before starting any program the needs of the roadsides in each town or area should be surveyed The appropriate treatment should be planned after the survey is made. Recommended techniques are given below A detailed discussion of these methods is found in Bulletin 624 of the Connecticut Agricultural Experiment Station, P. O. Box 1106, New Haven, Connecticut, which may be obtained upon request.

A. Stump Treatment

This is a very effective and desirable technique and should be used generally in conjunction with all cutting operations It involves cutting trees and other undesirable growth and treating with herbicide immediately before or after cutting. This method is effective in preventing resprouting and avoids "brown out" and unsightly standing dead stems. Since only treated stumps are killed, the ultimate in selective treatment can be achieved. The following formulation is effective:

a. 2,4,5-T low volatile esters at 8 to 16 pounds of acid equivalent per 100 gallons of spray in fuel oil, diesel oil or kerosene

b. 2,4-D plus 2,4,5-T low volatile esters at a combined acid equivalent of 12 to 16 pounds per 100 gallons of spray in fuel oil, diesel oil or kerosene.

The spray is directed at the cut surface of stumps on all sides and at the root collar or crown, which lies at or just below the ground line, so as to drench the stump and root crown The spray should be applied immediately after cutting If this is impractical, it may be delayed up to

1. Recommendations prepared by The Connecticut Shade Tree Committee
2. Chairman of the Connecticut Shade Tree Committee

three days although this is not recommended. In some cases, particularly if small trees are involved or excessive debris makes locating stumps difficult the stump spray maybe applied before cutting. Rundown to the root crown is important and stump spray should never be tried if the stumps are covered with water, ice or snow. Stump treatments with 2,4,5-T may be applied during any season of the year. Including an oil soluble dye in the spray mixture would enable one to tell which stumps have been treated Regrowth from stumps treated can be sprayed the following season, using stem-foliage or basal methods

B. Basal Treatment

Basal treatment involves the application of herbicides to the base of standing woody vegetation. It is recommended for use on smaller growth (4') and on regrowth from previous cutting and stump treatments. Basal sprays are very effective and can be applied just before cutting to avoid missing smaller stems, as is often the case in stump applications. Basal treatments are relatively ineffective for use on trees over 3" to 4" in diameter and are not recommended for use on tall growth which will prove unsightly if left standing. Basal sprays, being oil borne have a tendency to kill grasses and ferns, thus when brush and sprouts are dense, great care must be exercised to confine the spray to the stems and root crown or a "scorched earth" appearance will result the following year.

The same formulations as for stump treatment are used.

The spray is directed at all sides of the stem to a height of 15" to 20" and to the base of the plant. It is important to get rundown at the root collar. Basal treatment can be applied during any season of the year, but should never be used when the stems are covered with water, snow, or ice. For the control of root-suckering species such as sumac and sassafras summer basal sprays are most effective. All danger of damage to sensitive crop plants adjacent to sprayed areas can be avoided by treating before planting or after harvesting the crops. On the other hand, desirable species are more readily identified when the plants are in full leaf.

C. Stem-Foliage Treatment

Stem-Foliage sprays should be used for killing poison-ivy as well as for dense stands of undesirable growth where basal treatment is impractical The misuse of stem-foliage treatments in the past has led to serious consequences. Therefore, great care must be used in applying stem-foliage sprays. They present more of a hazard to susceptible plants by drift and volatility than stump or basal treatments and are more difficult to use selectively.

To permit maximum selectivity, equipment should be adapted to spray only the undesirable growth. Undesirable vegetation exceeding 4 feet in height should be cut and the stumps treated Undesirable woody growth less than 4 feet tall may be treated by either basal or stem-foliage methods depending upon the density of growth and the nearness of susceptible ornamental or crop plants.

The recommended materials for use in stem-foliage sprays are the low volatile esters or amine salt formulations of 2,4-D plus 2,4,5-T at 6 to 8 lbs. combined acid equivalent or 2,4,5-T alone at 4 to 6 lbs. acid equivalent per 100 gallons of spray in water. These herbicides will not destroy sedges and grasses.

Stem-foliage sprays are most effective when applied during the early summer but the resulting brown-out is pronounced over a longer period. The preferred practice from the aesthetic standpoint is to apply stem-foliage sprays from August to early September, just before natural autumn coloration begins. At this time, brown-out by foliage sprays will be much less objectionable.

For maximum kill, foliage sprays should wet stems of foliage to run down. Desirable shrubs should not be sprayed. Special precautions should be taken to avoid hazards of volatility and drift (See Bulletin 624, P. 9). On roadsides adjacent to susceptible ornamental plants or crops, stem-foliage sprays are recommended only with nonvolatile materials such as ammonium sulfamate or amino triazole. In these areas, however, basal or stump treatments should be considered because ammonium sulfamate or amino triazole compounds are nonselective and kill all vegetation including grasses causing unsightly brown out. For a list of desirable plants native to Connecticut and the tolerance of various plants to foliage sprays of 2,4-D and 2,4,5-T, see Bulletin 624

D. Other Methods

Fenuron pellets are not recommended for use along roadsides because desirable trees and shrubs with roots growing into the treated areas will be killed or injured.

Recommendations for the use of Herbicides along Connecticut Town Roadsides prepared by the following organizations under The Connecticut Shade Tree Committee -

The Connecticut Agricultural Experiment Station
The Connecticut Botanical Society
The Connecticut Cooperative Extension Service
University of Connecticut
The Connecticut Light and Power Company
The Connecticut Park and Forest Association
The Connecticut Board of Fisheries and Game
The Connecticut State Highway Department
The Hartford Electric Light Company
The Southern New England Telephone Company

HJC:nam
7/7/60

HERBICIDES AS A LANDSCAPE TOOL FOR ROADSIDES

William C. Hall[1]

Plants along roadsides are viewed by the Public with various reactions, mostly pleasurable. Some plants are dangerous or noxious, and these are weeds. The problem is to retain the desirable plants and eliminate and replace the others.

A roadside is a manipulated environment even when it winds through a virgin forest. The exposure to sunlight encourages growth somewhat different from that in the woods only a few feet away. Unplanned manipulation has various results, which usually have neither the advantages of the natural nor those of the maintained. Undesirable, woody vegetation grows up, obstructing drivers' vision on road turns and shading out other plants. Cutting and spraying with herbicides are methods used to overcome this problem. Cutting encourages the regrowth of more stems than had been cut. Blanket spraying has resulted in the elimination of not only the undesirable, but also of desirable, low-growing, woody shrubs, not a driver hazard; also eliminated are nearly all of the broadleaf herbs, leaving a cover of only grass, this often on a site difficult and expensive to mow. How much more attractive, how much more practical it would be to end up with a planting of mixed, low, flowering shrubs and wild herbs which, with no hazard to driving and a minimum of maintenance expense, will provide attractive flowers, foliage coloration, and fruits, and give pleasure to all those who go by.

Herbicides used selectively can eliminate the undesirable and leave the desirable. This has been done in many places, and recognition of this is now accepted. Much blanket spraying is, unfortunately, still being done, as the size and appearance of equipment and a lower cost per mile for one treatment of the roadside are given more weight than the desirability of the end result.

Much of the blanket spraying does not even eliminate the woody brush and poison ivy it is applied to kill, as it is applied to the entire roadside in a weak mix which only teases the brush, but does destroy the vegetation which should be preserved. This is because such a mix applied rapidly by big machines costs little per mile.

Why not landscape roadsides by killing what you want killed and leaving what you want to keep? Follow time-tested methods[2], of selective herbicide usage for this purpose, and your roadsides will successfully serve their full purpose. There will be no view-blocking brush, no noxious plants; the roadsides will be attractive to look at and inexpensive to maintain.

1. President, Chemtree Corporation, Harriman, New York
2. Bulletin #11, The Connecticut Arboretum

NATURAL LANDSCAPING WITH HERBICIDES

William A. Niering[1]

Since 1953 the Connecticut Arboretum at Connecticut College has been conducting various research projects involving the use of herbicides. A right-of-way demonstration area has been established to exhibit sound vegetation management principles. A report on this project appears as a separate article in these proceedings. (1) In addition, weed-killers are being used in controlling undesirable vegetation in the native tree and shrub collections and forest plantations. They are also being utilized in creating favorable wildlife cover and in natural landscaping. The purpose of this report is to describe how chemicals can be used to beautify the landscape with the existing native species. It was Woodward (2) who first pointed out the potentialities of creating an aesthetically attractive landscape by selectively eliminating undesirable forms and preserving the attractive ones. Probably no region has a greater array of attractive ornamental native trees and shrubs than the northeast. These have become especially conspicuous on land abandoned from agriculture.

At the Connecticut Arboretum two areas have been designated for this purpose. In 1953 a portion (350' x 100') of a hillside abandoned from agriculture, which had developed a thicket vegetation with scattered trees and grassy openings, was selected for experimental work. Later another plot (75' x 75'), within the cultivated portion of the Arboretum, was also set aside. Those shrubs and low-growing trees considered ornamentally desirable and present in these plots are listed below:

> Wild rose, high bush blueberry, common barberry, huckleberry, bayberry, Virginia creeper, flowering dogwood, red cedar, gray birch, ground juniper, meadow sweet, chokeberry, mountain laurel, shadbush, arrowwood and sumac.

Undesirable species to be removed or at least reduced in abundance included:

> Blackberry, poison ivy, sumac, black cherry and other scattered tall-growing trees.

The objective was to create a shrub-herb type community by selectively reducing or eliminating undesirable competitive species.

<u>Technique</u>: To accomplish this the herbicide technique most commonly employed was the basal or root-collar treatment which involved thoroughly wetting the bases of the stems or root collar region of the undesirable species. On trees over 3-4" in diameter notching or frilling the bases prior to treatment is recommended. The typical formulation employed was

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[1] Associate Professor of Botany and Assistant Director of the Connecticut Arboretum, Botany Department, Connecticut College, New London, Conn.

2,4-D -- 2,4,5-T, 1 part of chemical to 20 parts of fuel oil. Ammate crystals were also effective when placed in the frills. Although no trees were cut and stump treated, this technique may also be employed. Following cutting, the stumps are soaked using the above formulation. To control sumac, late summer basal applications reduced suckering to a minimum. On blackberry spring treatment using the 1:20 formulation has given best results. However, in all cases with blackberry, follow-up sprays were necessary. In the herbaceous stratum, a mixture of grasses as well as broadleafed flowering species such as asters, goldenrods, Queen Anne's Lace, black-eyed Susans, butterfly weed, daisies and chickory are all attractive forms to be perpetuated. However, if other weedy species become too abundant spraying may be necessary. On difficult to kill herbaceous perennials a 4-6 per cent 2,4-D --2,4,5-T in water is effective with follow-up treatments. For less difficult herb species a 0.3-0.5 per cent 2,4-D in water is effective. (2).

Present Aspect: After seven years the former thicket type habitat now exhibits a most attractive semi-open aspect in contrast to the control area which is dominated by a dense thickety cover of sumac, bayberry, poison ivy with scattered cherry up to 18' in height. In the foreground of the landscaped area, openings are dominated by such beautiful grasses as broomsedge and red top along with goldenrod. Beyond, scattered shrubs such as high bush blueberry, bayberry, huckleberry and low-growing trees such as red cedar and gray birch have been accentuated by removal of competative forms. One vista up the slope carries our eye to a flowering dogwood serving as an accent species.

Use of weed-killers in this manner has unlimited opportunities for the individual home owner who has an abandoned field or pasture growing up with this interesting array of species. By selectively eliminating the undesirables one can create an aesthetically charming landscape around one's home with beautiful vistas and maximum opportunities of creativity in landscape design. This is also a unique way to stop or retrogress the normal succession to woodland thereby preserving many species which would normally be shaded out by larger growing forest trees. Wildlife also benefits in that songbirds and other animals find excellent food and cover.

When the desirable community is once created, mere spot treatment in the future is all that is needed to maintain this aspect of natural landscape.

Acknowledgments: The author wishes to acknowledge the following companies for supplying chemicals and equipment: Amchem Products, Inc., Diamond Alkali Co., Dow Chemical Co., E. I. duPont de Nemours & Co. and D. B. Smith & Co. Inc.

Literature Cited:

1. Niering, W. A. 1961. The Connecticut Arboretum Right-of-Way Demonstration Area: it's role in commercial application. N.E.W.C.C. 15th Ann. Meeting Proc.

2. Woodward, Carol. 1951. Taming the Landscape with Herbicides. Horticulture, Nov.

STATE HIGHWAY HERBICIDE POLICIES[1]

H. H. Iurka and Kenneth King[2]

In the belief that data obtained in the summer of 1960 for a report to Penn State's Forest Symposium would be of interest to personnel at this conference who might not obtain the original report the authors have obtained that symposium's approval to present this revision of the original report.

We should first understand the purposes of herbicide work on highways. Of primary importance is economy in our maintenance operations. The savings possible have been reported to and published by this Weed Control Conference and the Highway Research Board. Secondly there is improvement of safety and health factors by, for example, the elimination of weeds and brush to provide visibility at intersections, to provide visibility of guide rails and signs, and by the elimination of plants such as poison ivy and ragweed. While we Landscape Architects are sometimes hesitant to speak of appearance when dealing with the rough realism of budgets this purpose of herbicide work is a fortunate concomitant. Finally there is a matter of good public relations.

The uses of herbicides on highways are:

a. To control broad leaf weeds for the primary purpose of reducing the number of mowings necessary.

b. To control all vegetation along guide rails, around signs, posts, and other structures to eliminate the costly mowing previously necessary.

c. To control brush which as you all know was a very expensive operation before our modern herbicides became available.

d. To control weeds in plantings.

e. To eliminate vegetation in storage areas and in structural joints.

1. Revision of a report made at a Forest Symposium "Herbicides and Their Use in Forestry" held at the Pennsylvania State University 8/30,31/60 for presentation to the Northeastern Weed Control Conference 1/4-6/61.

2. New York State Department of Public Works.

We are looking forward to the day when a growth retardant will be available and proven for our use.

Now let us consider the hazards which go along with herbicide operations. There is of course misdirected application which may occur, although with skilled operators we should not expect it. There is the hazard of drift which is a very real one especially in an area such as ours where the wind seems to be blowing more than 15 miles an hour almost every day we want to spray. I think we all recognize that the factors here are wind velocity, pressure, nozzles, and susceptibility. There is the hazard of volatility, with the contributing factors of wind, temperature, humidity and susceptibility. With certain of our materials such as the relatively insoluble soil sterilants there is the hazard of washing beyond the area treated, with the factors of vegetative cover, soil type, rainfall, and concentration to be considered. Finally there is the hazard of the leaching of soil sterilants with the factors of soil type, rainfall, and concentration.

In addition to these normal hazards which we all must face there are errors of judgment, or should we say differences in opinion. Those of us with some experience with brush control abhor the term "brownout" with all that it implies of public and official criticism. Foliage spraying of brush is an effective and economical tool under certain conditions. We cannot afford to discard it, but the supervisor must know how far he may go with this tool for a specific location. If he does not exceed a reasonable application ("reasonable" not only to his superiors but to the vocal element of the public) his judgment is good. Granted the supervisor may succeed for years in using good judgment but let there be one unhappy case of unfavorable public reaction or unfavorable opinion on the part of an important official and the whole program may be adversely affected.

There is a field of argument about the definition of the word "weed". Not long ago at a convention of a national group of some importance a naturalist criticised severely the use of herbicides on the last remaining places where the native flora of our country might be found and studied. He was referring to wild flowers on our roadsides. Is chicory on highway shoulders or drainageways a wild flower or a weed? Within our own organization we know the answer. We mow these areas and so the herbicide treatment of them is no more destructive than mowing. However we are acutely conscious of the unfavorable publicity possible due to even such ill advised criticism.

There is a matter of judgment of the extent of our treatment. We can cover more area than essential and thereby defeat our program of economy. There is also the possibility of misuse of materials, for example not long ago it was found that 2, 4, 5-T was being used for control of weeds susceptible to 2-4D.

All the preceding are considerations that enter into the development of a program of effective use of herbicides to assure efficient control while obviating damage to plants that should be preserved and eliminating claims which are not only costly in themselves but possibly even more costly in their nuisance value. It takes time to sell a herbicide program. There is the natural reluctance of adminis trators to adopt a tool which has not to their knowledge and in their own experience been proven. There is the problem of justifying what seems like an additional expense to the officials responsible for disbursement of funds.

Within the organization of any agency attempting herbicide work there must be personnel with the necessary knowledge, competence and time to direct that work. There must be planning not only of daily operation but of yearly programming. There must be a definite assignment of responsibility and authority. There must be adequate supervision by competent personnel. Actual work must be done by trained personnel. There should be an unbiased appraisal of results not only of the current year's work but of previous work. There should be evaluation of the results with consideration at the same time of costs preferably with comparisons being made more than state wide.

To provide information of the present policies of the Northeastern States highway departments we requested the official responsible for the herbicide program in each of the states to provide us a statement of the policy of his department. The information obtained was assembled in tabular form and sent to each of the officials requesting correction of errors or omissions. The final tabulation is appended. Under the heading of "Regulation" is given the governing policies set up at a high level as distinct from the practices recommended at lower levels. For those of us who have followed the development of the use of herbicides by the highway departments it is interesting to note that most of these departments now have a broad program and that the volume of work has been increased significantly. In the authors' opinion there are two observations of particular interest. The first is that there is a relatively small amount of regulation at a higher level. The other observation is that it would seem that as a program develops more regulation at a higher level is to be expected.

DATA ON STATE HIGHWAY HERBICIDE POLICIES

OBTAINED THRU CORRESPONDENCE WITH OFFICIALS RESPONSIBLE FOR PROGRAM, 1960.

STATE HWY. DEPT.	HERBICIDE USE: Broad Leaf Weed	Rag-weed	Guard Rails etc.	Brush	Poison Ivy	Other	BY CONTRACT	BY OWN FORCES
CONN	X	X	X	X	X (and poison sumac)	Weeds in plantings. Growth inhibitions		X
DELA.	X		X				X	
MASS.	X		X	X	X		X	X
MAINE			X	X				X
MD.	X		X	X		Weeds in Plantings		X
NEW HAMP.		X			X			X
NEW JERSEY	X		X		x	Concrete Joints	X	X
N.J. TPKE. AUTH.			X			Growth Inhibtor		
NEW YORK	X		X	X	X	Weeds in Plantings		X
PENN.	X	X	X	X	X		X	X
RHODE ISL.	X		X	X	X		X (Most)	X
VT.	X		X	X	X			X
VA.	X			X				X
W. VA.								

DATA ON STATE HIGHWAY HERBICIDE POLICIES

REGULATION

CONNECTICUT: Control of aerial application of pesticides & fertilizers by Dept. of Aeronautics, Board of Fisheries & Game, Dept. Health, & Conn. Ag. Exp. Sta. Control of Chemical use in or adjacent to public water supplies by Dept. of Health. Control of Chemical use in other waters of state by State Board of Fisheries & Game. Selective work - avoidance of brownout. Recommended policy of vegetation control by Public Utilities by State Board of Fisheries & Game, etc. permit on state R.O.W.

MAINE: Weed and Brush Control Association (Highway Dept., most of Utility companies, and other interested parties) recommends "Roadside Spraying Code" as a guide, which includes limitation of 6' height of brush to be sprayed.

NEW YORK: Leaving of dead wood (fire hazard) in forests not permitted by Dept. of Conservation. Control of chemicals in waters of state which might be injurious to fish - Dept. of Conservation. Control of chemicals for aquatics by permit from Health Commissioner. Maximum 2' height of brush sprayed. Public Utility work along highways by permit. No 2,4-D or 2,4,5 T use permitted in vicinity of vineyards - D.P.W.

PENNSYLVANIA: Maximum 8' height of brush sprayed. Public Utility work along highways by permit.

RHODE ISLAND: Brush spray limited to stubs of brush cut in current year. No spraying when windy or near susceptible plants. Ammonium Sulfamate the only brush control chemical approved for public water supply lands.

VERMONT: Used under the personal direction of the District Engineers to avoid public criticism.

VIRGINIA: Maximum 3' height of brush sprayed. Foliage spray by special permisaion only. Public Utility work on R.O.W. by permit.

WEST VIRGINIA: Use of herbicides for the control of weeds and brush prohibited on state rights-of-way.

No other specific regulations given for other States in correspondence.

A WIND VELOCITY AND DIRECTION INDICATOR FOR AIRCRAFT BRUSH SPRAYING OPERATIONS

J.M. Bennett and G.L. Parker [1]

Abstract [2]

Aircraft application of herbicides to control brush on right-of-ways is an important part of the maintenance program of many utilities. The most serious restriction on aircraft spraying is suitable weather, as almost dead calm conditions are necessary to minimize spray drift. Lack of movement of tree leaves and absence of ripples on lakes have been the traditional indicators of calm weather used by field personnel. These methods, although primitive, have been satisfactory for most spray operations and drift damage has not been serious. With the extension of aircraft spraying to high steel tower lines, drift control has become more difficult due to the increased altitude. At spraying heights in excess of 100 feet, drift often occurs when there is no indication of wind by traditional means. A convenient method of measuring wind velocity and direction at various altitudes became essential for satisfactory spraying of right-of-ways under high lines.

Wind measurement was first attempted by observing the movement of the smoke trail produced by a signal flare fired vertically. Some indication of wind velocity and direction was obtained, however flares were not adequate. A separate flare was required for each reading and wind velocity and altitude could only be estimated.

A hydrogen-filled tethered balloon provided the solution to the problem. A balloon, tethered with nylon fishing line, was allowed to rise to the desired altitude and the angle of deflection of the line, produced by the lateral shift of the balloon, was correlated with wind velocity. The direction of the lateral shift corresponds to the wind direction.

Six-inch pilot balloons of the type used in meteorological studies were used in the equipment, designed to enable direct readings of wind velocity in the range of 0 to 5 miles per hour. Readings of wind direction and balloon height are also possible.

This wind velocity and direction indicator has provided more accurate and complete information on wind conditions than has been available to personnel on aircraft spray operations. With this information available, more efficient use of the limited calm weather is possible and spray flights can be planned to reduce spray drift to a minimum.

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1 Biologist and Chemist, respectively, Research Division, The Hydro-Electric Power Commission of Ontario.

2 Abstract of a manuscript to be submitted to WEEDS.

ROADSIDE BRUSH CONTROL WITH PHENOXY HERBICIDES IN THE NEW ENGLAND STATES

by

John B. Roy

INTRODUCTION

The development and sales of 2,4-D and 2,4,5-T Phenoxy herbicides during the past 15 years for brush control have provided the state highway departments, utilities, telephone companies, and towns with a tool that if properly used will benefit all. These public agencies with the use of these chemicals are able to give the public and the taxpayer better electrical and telephone service, and safer roads for each dollar spent than if hand and mechanical cutting of brush and weeds continued. The National Safety Council reports that one out of eight fatal automobile accidents is caused by poor visibility (1). Not all these accidents can be credited to uncontrolled vegetation; however, a significant percentage of these is caused by obstruction to vision from unwanted, uncontrolled brush. Brush that hinders visibility on curves, road crossings, and railroad crossings certainly should be eliminated for safety to the public. Also by the elimination of brush, areas are left for plowed snow, disabled vehicles have room to pull off the road for repairs, better drainage is obtained, and noxious weeds and brush such as poison ivy and ragweed are kept under control and even eliminated. The economics of chemical brush control is very favorable when compared with the cost of continual cutting and mowing.

EARLY BRUSH CONTROL WORK

Tests in 1945 and 1946 indicated that 2,4-D would control many woody species including willow, birch, aspen, alder, and sumac. Many species, however, were somewhat tolerant of 2,4-D, and utility personnel urged the chemical companies to develop a product which would be effective on certain problem species including bramble, oak, maple, ash, and hickory.

SCREENING

Screening tests in 1947 demonstrated that 2,4,5-T would control many of these species much better than 2,4-D. Manufacturers began to formulate mixtures of 2,4-D and 2,4, 5-T and called them Brush Killers. 2,4,5-T was more costly than 2,4-D and less of this chemical was used in some formulations. As work with 2,4,5-T increased and better results on problem species noted, equal parts of 2,4-D and 2,4,5-T in the brush killer formulation became standard. Ester formulations containing four pounds acid equivalent per gallon (2 lbs. of 2,4-D and 2 lbs. of 2,4,5-T) became extremely popular where the formulations were used for industrial brush control.

Several utilities in New England tested 2,4,5-T in the early '50s and found that good formulations gave as good control of 2,4-D susceptible species and far superior control of the "hard-to-kill" trees, brush and brambles than the combination with 2,4-D. The 2,4-D - 2,4,5-T combination was well established in the field and many utilities and highway departments in New England evaluated the use of 2,4,5-T prior to making the change. Today, approximately eighty percent of the phenoxy herbicides sold in New England for right-of-way use are straight 2,4,5-T formulations.

METHODS OF APPLICATION

There are at least five methods of application employed for roadside chemical brush control in New England. Three are most popular.

1. Foliage or Leaf-Stem Application. The foliage or leaf-stem application is economical and is widely used. Three to four quarts of a 4 lb. 2,4,5-T ester formulation are used per 100 gallons of water, and all leaves and stems of the brush are sprayed to point of run off. Most of the roadside brush control work is contracted, and the contractors use vehicles equipped with tanks of 400 to 1,500 gallon capacity with 15 to 35 gallon per minute pumps. Pressures vary from 100 to 400 pounds per square inch. Guns with quick shut-off are commonly used to lessen the danger of spraying areas adjacent to gardens and also of spraying desirable plants and shrubbery. Orifices used in the gun tips range in size from 10 to 14. This affords large droplet size and cuts down the danger of undesirable drift.

Spraying begins in Connecticut, Rhode Island, and Massachusetts about June 1 and in New Hampshire, Vermont, and Maine about June 15. For most effective results, it is important that the majority of leaves on woody plants are expanded fully prior to spraying and that the foliage program cease before fall coloration occurs. If an application is made prior to full leaf development, the spray may cause an excessively fast brown-out resulting in poor translocation of the chemical through the plant system. Poor control may be revealed as new growth or "flagging" on the stems and resprouting in the root collar areas. Best results are obtained when the leaves are adding food to the plant system. The theory is that the chemical has a tendency to travel with the plant food. Poor results can also be expected when the foliage is sprayed during a prolonged drought period or after frost in the fall. In both cases the plant is in a semi-dormant stage and reaction to the chemical is slow and usually poor.

From the standpoint of public relations, foliage spraying is normally limited to brush that is less than six feet tall. In Connecticut, Rhode Island, and Massachusetts it is desirable to spray before the brush is four feet high. There have been numerous complaints in New England during the past five years concerning the brown-out which follows a summer foliage application with phenoxy herbicides. Most of these complaints come from residents in areas where brush has been sprayed at heights considerably greater than six feet, even as high as 10 to 15 feet. During July, 1957, the town of York in the state of Maine sprayed many of the town and state roads in the area. This town, as probably many of you know, is visited by many tourists during the months of July and August. The brush sprayed was less than six feet in height, and, as a result, there was not one complaint by tourists or townspeople concerning brown-out.

Volumes of spray range from 150 to 250 gallons per acre with an average of 200 gallons. Height and density of brush determines the volume used. Width of roadside sprayed varies from 6 to 20 feet with an average of 12 feet. The cost per mile is from $20 to $40, depending on density, height, and width of the brush. The average cost is $33 per mile.

Normally, at least 60% of the stems and roots are controlled with an initial application. A second foliage treatment is made the following year or two years later.

The cost of this is approximately the same as the initial cost, the reason being that where much of the brush has been eliminated, low-growing, undesirable vegetation has been released, and along with the brush not eliminated by the initial application, the spray vollume needed in the second application is about the same as that in the first one. Two applications two years in a row normally are sufficient to put a distribution line or highway right-of-way under excellent control. A third application is made two or three years later. This one is usually a basal treatment, the second most widely used application method in the New England States. Some utility and state highway personnel feel that three foliage applications are desirable before a change to the basal program.

2. Basal Treatment: Adequate evulation of basal and stump treatments came somewhat later than for foliage treatments. Two, three, or four gallons (8, 12 or 16 pounds acid equivalent) of 2,4-D, 2,4-D + 2,4,5-T or 2,4,5-T ester formulations were mixed with 100 gallons of kerosene, fuel oil, or Diesel oil and applied in widely scattered field tests. It was soon established that 2,4,5-T was the most active of the three chemicals and that four gallons (16 pounds A.E.) per 100 gallons of oil gave the most uniformly effective root kill. These applications were made mostly with knapsack sprayers. With power equipment, three gallons of 2,4,5-T in 100 gallons of oil gave comparable results. Usually higher spray volumes were utilized and in actuality, the same amount or even more actual chemical was applied. Low pressure is important and 25 - 50 pounds per square inch is desirable.. Application is made to all of the lower part of the stem 12 to 18 inches above the root collar. It is important to wet the stem thoroughly and completely to have a sufficient run-down onto the entire root collar area. Best results are obtained when the entire root collar is thoroughly wetted by the chemical mixture. Snow, ice, leaves, and sawdust accumulated around the root collar could lead to poor control. Poor control also may result when the lower stems are submerged in water. Volume of chemical mixture in a basal application varies from 20 gallons per acre where the basal method is used as a follow-up spot treatment program up to more than 100 gallons where this method is used as the initial application. Both small hand guns and wands are used in applying the formulation. Again, orifice size is important to reduce the possibility of drift. Orifices ranging from Nos. 3 to 5 are the most popular.

Basal applications can be applied effectively any time of the year if the chemical mixture is applied properly. Such application frequently costs 50% or more than the foliage program. For this reason the initial application method along roadsides usually is not basal. When a high percentage of the undesirable hardwoods has been controlled by foliage application, basal application then becomes economical. It is also very selective and the desirable, low growing shrubbery can remain unharmed.

3. Stump treatment: Stump treatment is the third method of application used widely in the New England States. The mixture is the same as for basal treatment, using 3 to 4 gallons of a 4 lb. 2,4,5-T formulation in 100 gallons of fuel oil, Diesel Oil, or kerosene. This application is used frequently where an area is first cleared or re-cut. It is important, as with basal application, to treat the stump completely to point of run-off in the root collar zone. Less volume usually is applied to stumps than with the basal application due to the lesser bark area covered. This results in reduced cost; however, the percentage of human error is somewhat increased. Volumes of chemical mixture applied per acre range from 35 to 60 gallons with an average of 45 gallons.

4. Dormant Broadcast: Dormant Broadcast application, using 2,4,5-T at a gallon and a half (6 pounds acid equivalent) in 100 gallons of oil is presently being evaluated. The results thus far indicate good stem kill; however, more resprouting has been noted than with the basal method of application.

5. Invert Emulsions: Invert formulations containing 2 pounds of 2,4,5-T per gallon are also presently being evaluated for roadside chemical brush control. Inverts are formed by adding water to a special chemical oil mixture with continuous agitation. The oil and chemical surround the water particles and a mayonnaise-like mixture is obtained. This invert mixture varies in consistency from that of mayonnaise to a thick paste. The consistency of the material depends on the relative amounts of oil and water in the mixture. Tests were made in the Spring and Fall of 1959 in the states of Maine and Connecticut, and in the Spring of 1960 in Connecticut using from 1-1/2 gallons to 3 gallons (of the 2 pounds 2,4,5-T acid equivalent gallon) with 14 gallons of No. 2 fuel oil in 100 gallons of water. The complete stem was sprayed prior to bud-break in the Spring of 1959, and the results were excellent. Fall applications the same year in Connecticut, using the same

mixtures and treating the base of the plant as with a basal treatment, using 2,4,5-T in oil, gave fair to good results. The plants that leafed out the following spring began to die in July. No appreciable brown-out was noted. Tests were made in the Spring of 1960 in Connecticut with a basal treatment prior to bud-break with results definitely better than the late fall dormant application. From observations of the 13 tests made in New England the past two years, additional testing appears necessary, and this work is planned for the Spring of 1961, prior to and after bud-break with a treatment of the entire stem. Methods of application have to be further evaluated. With the information that has been accumulated during the past two years, and from trials planned for 1961, we hope to have some concrete data on the use of invert formulations for roadside brush control with ground equipment by the end of 1961.

Roadside brush control with phenoxy herbicides has increased from 200 miles in 1954 to more than 4,000 miles in 1960 throughout the New England States. Most of this work has been with the state highway departments, utilities, and the telephone companies. Educational programs have been presented in two of the states to inform the public of the nature of these materials from the standpoint of toxicity and the temporary brown-out feature. The phenoxy chemicals have become an important tool in the maintenance programs of most people connected with brush control.

Literature Cited:

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"MASSACHUSETTS PROGRESS REPORT ON RESEARCH WITH MALEIC HYDRAZIDE"

JOSEPH L. BEASLEY[1]

The grassed areas of the 2,400 miles of State highway in Massachusetts present a continuous mowing problem to the personnel charged with the responsibility of their maintenance.

Experience has taught us that there is no single phase of our roadside development operations that can be termed a "cure all" for a reduction in mowing costs. It is rather a well planned combination of:

(1) Planting and mulching
(2) Contract mowing
(3) The use of Maleic Hydrazide (MH-30) as a grass growth inhibitor

Planting and Mulching

Since we are not interested in growing grass, the planting of seedlings, vines, prostrate shrubs and natural growth sod takes place on new roads immediately after the completion of the prime contract for the construction of the highway itself.

In all areas where ground cover is practical, this second contract for planting and mulching removes such areas from the necessity of future mowing.

Contract Mowing:

The second phase in our war against increasing costs is the practice of mowing grass by contract.

Massachusetts is a pioneer in the field of mowing grass by contract. After a number of trials and revisions, it is felt that we have the most practical mowing specifications in the country. When you consider that the grass on each and every mile of our State highway system is mowed annually, and that our contract mowing costs per acre are as low as any state in the country (with comparable standards), our maintenance personnel may be justified in feeling proud of themselves.

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[1]Highway Landscape Supervisor, Massachusetts Department of Public Works.

Currently, the number of cuts per year vary with the type of grass to be mowed.

Lawn type mowing requires eleven (11) cuts per season; roadside hay mowing five(5) annual cuts while hay mowing is confined to one (1) seasonal cut.

The Use of Maleic Hydrazide (MH-30)

The third, and by no means, least important phase in reducing mowing costs is the application of certain chemicals to retard the growth of grass, which will automatically reduce the number of mowings required at present.

Since 1953, Massachusetts has been experimenting with chemicals in this area, and it now appears that the most effective method of obtaining a uniform growth of grass is by the proper application of the following spray solution:

100 gallons of water
1 gallon of 2,4-D
4 ounces Spreader Sticker
2 2/3 gallons of MH-30

Since the solution is being applied at the rate of 75 gallons per acre, it is estimated that two gallons of MH-30 per acre is the minimum quantity to insure proper coverage. While this ratio is higher than that recommended by the manufacturer, it guarantees that sufficient MH-30 is delivered to the grass.

Application

While the combination of MH-30 for inhibiting grass growth plus 2,4-D for eliminating succulent weed growth is unquestionably the correct solution, neither of the two will accomplish the desired results unless they are properly applied. Here we reach the as yet unsolved problem of designing the correct spraying equipment to be manned by competent and conscientious operators.

Since the cost of the material is considerable, it is felt that the manufacturers have given too little thought to the application of the spray solution on a large scale basis. The recent experimental field work indicates that the correct amount of MH-30 (as determined in the laboratory) is not always delivered to the grass. As we have agreed that the material will control the growth of grass if correctly applied, the fault must lie with the equipment and operators.

Again, since the solution is rather expensive, in order that there be neither overlapping, nor omission during spraying, some means must be devised to identify what area has been covered. Some thought has been given to equipping the vehicle with a separate nozzle for pouring a colored liquid dye to outline the outside edge of each spray pass.

Suggested Equipment Units for Applying Solution

For median strips up to 40 feet, roadsides, outside edges of interchanges, and narrow dividing islands:

One (1) 1,000 gallon tank truck with extender arm type boom, hydraulically operated, a minimum of 20 feet in length.

For wide median strips and dividing islands (over 40 feet), lobes and bowl areas of interchanges and other "hard to reach areas":

(a) Two (2) jeeps or equivalent vehicles (4-Wheel Drive) with dual tires on rear.

(b) One (1) 250 gallon tank.

(c) Fixed horizontal boom.

(d) Mast type boom.

(e) Hand operated boom with hose attachment for manual spraying of slopes, around trees and shrubbery, and other inaccessible areas.

In addition, a 2,000 gallon tank truck to be used to supply water to mix new batches of solution in the tanks of the above-mentioned spraying vehicles.

History of Inhibitor Experimentation on Grassed Areas

Massachusetts' research in this field began with MH-40 in 1953 with twelve (12) half-acre plots on Route #1 in Danvers, with encouraging results.

The following year selected areas on a much larger mileage scale were treated on a state-wide basis. While results in certain instances were desirable, other areas, because of poor application, were none too conclusive.

In 1960, the advent of MH-30 influenced the Department to further research in an effort to sabotage the rising mowing costs.

Approximately 75 acres embracing all types of grassed terrain were treated in the Springfield area. In addition, throughout the State, eight miles of median strips, roadsides, and a large bowl area received applications of the solution. This large scale experiment has indicated that the correct application will produce the desired results.

MH-30 will receive a stern test in Massachusetts, since our contract mowing costs per acre are low, while our standards are high. If MH-30 can reduce the costs per acre even further and still maintain our well-groomed grassed areas, it will prove that "chemical mowing" is here to stay.

Research in recent years indicates that this material (properly applied) will insure a uniform growth of grass (5" to 7") that will require only a minimum number of cuts per season. It is not necessary to have a "golf course" appearance to our grassed areas.

In the spring of 1961, Massachusetts plans to treat three (3) of its contract mowing areas in their entirety with MH-30. These three projects total about 65 miles.

Route #9 - Brookline to Worcester (2 contracts)
Route #128 - From Route #9, Wellesley to Route #1, Westwood (1 contract).

The Special Provisions for the above mowing contracts for these areas will call for a reduced number of lawn type mowings from eleven (11) to four (4) and those of the roadside hay cuts from five (5) to two (2).

In the fall of 1961 we also plan to apply this solution to other grassed areas. In the spring of 1962, it is expected that the number of mowing cuts ordinarily required in these areas will be reduced exactly as described above.

The fall application is being considered for two reasons:

(1) the amount of rainfall during these months is generally less than any other potential spraying period of the year.

(2) the MH-30 will be applied just prior to the time when the grass becomes dormant, and therefore will be present to inhibit before the grass begins to grow in the spring.

Statistics

In 1959, the low bids for our mowing contracts totalled about $580,000.00. The breakdown is as follows:

Type	Cost	Percentage of Whole
Lawn Mowing	$134,000	23%
Roadside Hay Mowing	$396,000	68%
Other Hay Mowing	$ 50,000	9%

Contrary to popular belief, these figures indicate that mowing costs for grassed areas on roadsides and interchanges are about three times those for median strips.

In 1961, our estimated mowing costs for 85 contracts will be about $628,000.00. The increase is directly attributable to the increased acreage to be mowed.

However, it is expected that, in the foreseeable future, that the combination of (1) planting and mulching, (2) mowing by contract and (3) the use of MH-30 inhibitor will reveal a savings of $100,000.00 per season in mowing costs.

A further analysis of our mowing statistics indicates that $300.00 per mile per season are expended to mow grassed areas on double-barrelled and limited access highways. When our three-fold plan is coordinated, this cost will be substantially reduced.

Summary:

Massachusetts, as well as other states, is facing a tremendous task in order to reduce mowing costs.

While planting and mulching will eventually cut down the grass acreage, there will still be large areas where the correct application of the MH-30 solution appears to be a life-saver in the sea of rising costs.

METHODS OF APPLYING MALEIC HYDRAZIDE

David G. Grimm [1]

In the fall of 1959, the first test plots using maleic hydrazide to inhibit the growth of grass were begun in the northern sections of the New Jersey Turnpike. The purpose of these trials was to familiarize ourselves with the problems that might confront us if a large scale operation were to be initiated. The results of these initial tests will be discussed in detail by Mr. Paul Bohne, Naugatuck Chemical Division, U.S. Rubber Company.

However, in the late fall before dormancy, in the area around Hightstown, we treated approximately five acres. Because of this particular test and inconsistent results observed the following spring of 1960, we realized we had to search for a more practical method of applying maleic hydrazide.

It would be to our advantage to discuss the Hightstown experiments. A 200 gallon spray tank, trailer mounted, rigged with a Hudson all-purpose spray boom, was used. The boom had 13 nozzles, and was set at 17 inches above grade. The amounts of material used are relatively unimportant at this time. This entire unit was conveyed by a jeep. At no time during the application did the operator change the height of the boom or regulate the controls. The entire bowl area was treated with no regard for overlapping. The results showed evidence that maleic hydrazide definitely inhibited the growth of grasses. The degree of inhibition varied with the rates of maleic hydrazide applied. The limiting factor in this test was the method of application. Severe browning out occurred on all turns. It was obvious that three or four turns were made at the same location. As the unit moved along the terrain, the height of the boom varied tremendously. At times the boom was within six inches of the grade, accounting formany skips in the spray pattern. Every dip, every roll in the grade added to the irregularities of the spray apttern. It was necessary to mow this lawn area in order to maintain the turf at an even height. A general observation that may be of interest was the reduction of broadleaf weeds. The fall application prevented

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formation of seed heads. It was also of interest to note that, in spite of the apparent failure, the over-all observations led us to conclude that we were the limiting factor--we, and not the chemical or the weather. If a program using growth inhibitors is to be effective, it is necessary to find ways of improving the methods of application, trying to work around the factor of human error, for, unlike 2,4-D, it is non-volatile and it is only effective on grass with which it has made contact and by which it has been absorbed.

During the year 1960, the New Jersey Turnpike tried four different types of chemical applicators. These shall be discussed individually, starting with the experiments in the southern division.

RESULTS OF TESTS - SPRING 1960

In the southern district of the New Jersey Turnpike, test plots were set up twenty feet wide on the back slopes. Here we used the same apparatus as described above, with the exception that it was conveyed by a tractor equipped with a tachometer. The basic turf in these areas consisted of fescue, blue grass, and some rye, plus weeds. These experiments started on May 5, 1960. The weather was ideal. The turf had been mowed to a height of four inches. (All mowers on the Turnpike are set to maintain the turf at this height.) As the material was being applied, the booms were adjusted to conform with the grade so that the boom was held constantly between 17 and 20 inches from grade. The Hudson spray boom is made up of three sections of angle iron hinged together so that the center section remains rigid and the right and left wings may be raised or lowered independently of one another. Details for the rigging and the setting of the unit are listed below.

A. 18 foot adjustable boom, 17 inches from grade
B. 13 nozzles #8003E, set 20 inches oc
C. Pressure, 30 pounds
D. A 200 gallon solution containing 10 gallons MH-30
E. Speed, 2 miles per hour

The goal was to apply 6 pounds active maleic hydrazide per acre, with 40 gallons of water per acre. On June 20, 1960, the annual broadleaf weeds reached a height of approximately six inches in the test plots. It was necessary, therefore, to treat all plots with 2,4-D on this date, at the rate of 3 pounds active per acre. Width of the test plots was 20 feet. The back slopes, in general, are 80 feet wide, thus leaving 60 feet untreated. A comparison was made, and the number and dates of mowings were recorded.

May 13	-	Untreated areas mowed. No mowing required on plots.
June 13	-	" " " " " " " "
June 21	-	" " " " " " " "
June 28	-	" " " " " " " "
July 13	-	" " " " " " " "
August 2	-	" " " " " " " "
August 10	-	" " " " " " " "
August 15	-	Treated areas were mowed.

On August 15, the invasion of crab grass made an uneven, unsightly appearance, and it was necessary to mow the treated areas in order to maintain the general attractiveness.

CONCLUSIONS

1. Seven mowings in this area were eliminated.
2. Maleic hydrazide inhibited the growth of desirable grasses.
3. A uniform distribution of the maleic hydrazide had been obtained.
4. For the development of a sound program using maleic hydrazide, it is necessary to further treat areas with herbicides to control broadleaf and annual weeds.

REMARKS

In the future, on all areas treated with this type of apparatus, to further insure that the height from grade remains constant, the two wings of the boom should float so that they will maintain the desired height. This may be accomplished by fabricating the booms with 17 inch bicycle wheels mounted at the extreme ends of the booms, allowing them to raise or lower whenever contours change. It would be an improvement to mount all controls within easy reach of the tractor operator so that he might shut off the unit without stopping whenever making turns, thus eliminating overlapping. Over an expansive, relatively flat area, this method would be a satisfactory way of applying maleic hydrazide, although results will rely tremendously upon the conscientiousness of the operator.

In our northern division, we contacted a commercial spraying company and arranged a demonstration of its hydraulic spraying apparatus. This unit has been used extensively throughout New Jersey in roadside spraying for the control of brush and broadleaf weeds. Our object was to test this unit's ability to give a uniform distribution for a 30 foot wide swath. To measure the distribution, Petri dishes were placed at 5 foot intervals, the closest being 5 feet from the truck, progressing to 30 feet. The equipment used contained four nozzles mounted on the side of the truck, each one calibrated individually by pressure. 150 gallons of solution were used containing 5 gallons of maleic hydrazide. A total of three acres was treated. The angles of projectory were manually controlled and set at the discretion of the operator. The speed of travel was 5 miles an hour. We observed that the operator had difficulty holding the spray pattern consistent. The nozzles directed at distances of 15 feet and 30 feet were relatively unstable, and breaks occurred in the spray pattern at these locations. This difficulty was caused by environmental winds and gusts created by passing traffic.. The break in the pattern becomes obvious as we review the table below.

Distance of Petri Dishes from Truck	Parts Per Million Maleic Hydrazide	Pounds Active Maleic Hydrazide
5	112	3.2
10	160	4.6
15	64	1.8
20	22	0.6
25	39	1.1
30	67	1.9

Average is 2.2 pounds active maleic hydrazide per acre.

NOTE: Petri dish - 0.35 square feet each.
The Petri dish is not an accurate system of measuring distribution, but it is a method of measuring.

No definite conclusions could be reached, but we can assume that this unit could be used for spraying maleic hydrazide effectively and uniformly for distances up to 25 feet. No record was kept regarding the inhibition of grass, although inhibition was evident throughout the season.

The next unit we used in our tests for spray distribution was a row crop mist blower. This unit was calibrated as follows:

A. 50 gallons water per acre
B. 6 pounds active maleic hydrazide per acre
C. 8 nozzles
D. 350 to 400 pounds air pressure
E. Angles of nozzles set for 5 to 50 foot swath
F. Speed, 5 miles per hour

We employed the same system of measuring distribution as in the previous tests.

Distance of Petri Dishes from Truck	Parts per Million Maleic Hydrazide	Pounds Active Maleic Hydrazide
5	98	2.8
10	32	0.9
15	21	0.6
20	59	1.7
25	102	2.9
30	109	3.1

Average is 2 pounds maleic hydrazide per acre.

From these results, we will note the variance in the distribution. During the operation, it was observed that the spray pattern hit at a distance of 50 feet, but the spray particles rolled out for an additional 20 feet. This was covering a far larger area than anticipated. However, this variance can be controlled by using nozzles that produce a larger particle size, and by changing the angle of projectory. A limiting factor with this type of application would be one of wind. This type of operation would be effective only on relatively calm days, and its use restricted to back slopes.

The New Jersey Turnpike passes over the city of Elizabeth with a series of fifteen overpasses, the slopes of which are in turf. This series of fifteen bridges is spread throughout a distance of one mile. The turfed areas are completely fenced in, making it impossible to mow economically. These areas were treated with maleic hydrazide. For this we used a hydro-seeder adapted to operate a conventional high pressure spray gun. This machine was calibrated as follows:

A. 200 gallons of water per acre
B. We would try for a 40 foot swath
C. 8 pounds of active maleic hydrazide per acre

The gun was manually controlled and the distribution was obtained by a sweeping motion with the gun. The results of this test were unsatisfactory because of the uneven distribution of the material. It was necessary to mow the grass in this area to a height of four inches. To mow ten acres of this turf required four men, working an eight hour day and a five day week, four weeks or 640 man hours. After the completion of the mowing operation, and in desperation, again we treated the area with a growth inhibitor. This time a high pressure spray gun was not used. Instead, we used the conventional nozzle for a hydro-seeder, the orifice of which is one inch inside diameter. However, it had one modification. To this nozzle a one inch wide steel strip, approximately 12 inches long, was fastened. The strip extended in front of the nozzle for about 7 inches. The last two inches of the steel strip was bent at about a 30° angle. With a pressure of 180 pounds, this modified nozzle gave us a 60 foot spray pattern. The water particles were well broken up but heavy enough so that a speed of 5 miles an hour had no effect on the spray pattern. These slopes were then treated using 200 gallons of water per acre, 8 pounds active maleic hydrazide per acre, and with the truck traveling at a speed of 5 miles per hour. The spray gun now was held rigidly in place by the operator. The slopes were treated in twenty minutes. Observations noted two weeks after treatment were a uniform browning off of the slopes. Growth had been inhibited. The browning off lasted for about a week longer, when color started to come back into the turf. This area was treated in July and no significant growth has occurred to this date.

This more or less concludes the work that we have done with methods of application. We have laid out test plots this fall varying the rates of maleic hydrazide between 4, 6 and 10 pounds active material per acre. Studies have been laid out to dete mine the amount of water necessary for an even distribution of material. The rates used are at 10, 20 and 50 gallons of water per acre. In the spring of 1961, the hydro-seeder will be modified so that 20 gallons of water per acre can be distributed with nozzles mounted on the side of the truck and operated by the driver from within the cab. This unit will be used to treat the ninety miles of grass median on the Turnpike. The nozzles will be set to cover 7 to 25 foot swaths. This median will also be treated with fertilizer and treated with herbicides for the control of both perennial and annual weeds. I believe that, by using this tool, we will not eliminate mowing altogether, but we will reduce significantly the amount of mowing recuired throughout the growing season.

METHODS OF SAMPLING RAGWEED POLLEN[1]

Eugene C. Ogden[2] and Gilbert S. Raynor[3]

Recent experiments have shown that pollen capture by the standard Durham sampler (Durham 1946) is determined by several factors, in addition to the concentration of pollen in the air (Ogden and Raynor 1960).

The combined effects of wind speed and wind direction may introduce differences of over 500 percent between samplers. The number of hayfever days and the ragweed pollen index computed from such data may show wide variations, even though the same concentration is being sampled. Aerodynamic factors are responsible for the greater collecting ability of the slide when its long axis is placed parallel to the air flow. Orientation of the slide with respect to wind direction may result in a 5 to 1 difference in catch between adjacent slides. The amount of pollen captured is also a function of the amount of air passing over the slide. An increase of 3 or 4 miles per hour in the wind speed may give more than a 50 percent increase in the pollen captured. Current practice in exposing slides without regard to these variables yields data which cannot be properly compared from one station to another nor from one day to the next at the same station. Since comparability is essential in many applications of the pollen count, greater uniformity in sampling is desirable. If the Durham sampler continues to be used, it should be oriented with wind direction. This is accomplished by mounting the sampler on a wind vane. Varying wind speeds present a more difficult problem. Perhaps the most suitable solution is to measure the total air passage over the slide and to correct the count by a factor determined experimentally.

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Modified Durham Sampler

An alternate method of overcoming the directional bias is the use of a square slide in a streamlined circular holder. One of our designs allows the air to flow smoothly over the surface, even at high speeds, as evidenced by wind tunnel tests. This sampler has two improvements over the standard Durham sampler: equal orientation with any air flow and less modification of approaching air currents. It retains the other advantages and disadvantages.

Cylinder Samplers

A cylindrical surface of suitable size is a reasonably efficient collector of particles in the pollen size range at any but low wind speeds. As an added advantage, an equation has been developed for describing its efficiency mathematically. The collecting efficiency varies directly with wind speed, particle size and particle density and inversely with cylinder diameter. In sampling ragweed pollen on a cylinder of fixed size, wind speed is the only variable and a curve of collection efficiency vs. speed may be constructed. Although small cylinders are more efficient, they tend to overload too quickly for 24-hour samples, especially in dusty air, and some compromise between efficiency and length of the sampling period is necessary. Cylinder samplers are mounted in a vertical position on vanes to keep the sampling surface oriented into the wind.

A cylinder large enough to accept a standard glass microscope slide in a vertical position on the leading face, without too much alteration of the cylindrical shape, should be 4 inches in diameter. This is too large for proper sampling at the usual wind speeds. To retain both the standard size slide and the smaller cylindrical shape, 1-x 3-inch slides may be made of thin (0.4 mm.) transparent plastic and attached to the side of a smaller cylinder (1 7/8-inch diameter) in a curved position. After a 24-hour exposure, such plastic slides will return to their original flat shape. Storage and pollen counting are essentially the same as with glass slides.

A cylinder sampler with 1/4- or 3/8-inch diameter has improved efficiency at low wind speeds. This may be made of transparent plastic rod (lucite or plexiglass) with a 1/16-inch wide flat portion formed on the side facing the wind. The same sticky medium (we prefer silicone grease) as used on the microscope slides is applied to the forward face of the cylindrical rod. The pollen remains on the rod while being counted. The grains may be stained by dipping the rod into Calberla's solution for a few minutes just before counting. Tests indicate the loss of grains in the solution to be slight. For counting the pollen, the transparent rods are placed into a contrivance that is gripped by the stage micrometer and has adjustments for leveling the surface to be examined.

We are now using a further modification: the slide-edge-cylinder sampler. This device utilizes the one millimeter edge of a glass microscope slide for the sampling surface. The slide is gripped between two plano-convex rods so its greased leading edge forms a portion of a 1/4-inch vertical cylinder. After exposure the slide is stored in a standard slide box with the sample surface up. The samples are counted by placing two exposed slides in a transparent holder to bring the greased edges parallel a centimeter apart. They may be stained and covered with a 22- x 50-mm. cover glass. The pollen grains on the 1- x 50-mm. strip are easily recognized and counted.

Some other types of samplers are available that utilize the principle of collecting on cylinders but either the accuracy of collection or ease of reading the samples leaves much to be desired. Cylinder samplers are relatively inexpensive but require a totalizing anemometer for recording air passage since the efficiency of pollen collection varies with wind speed.

Rotorod Samplers

The basic sampler was designed by personnel of the Stanford University Aerosol Laboratory (Perkins 1957). It has the very great advantage of being practically independent of wind speed and direction and therefore wind vanes and anemometer readings are not needed. Its major disadvantage is that it cannot be operated continuously for a 24-hour day due to the large volume sampled and consequent overloading of particles. This sampler collects pollen by impaction on a pair of small rods whirled through the air at high speed. The collecting surface may receive the pollen directly, in which case the opaque rod is placed on the microscope stage and the counts made with some difficulty, or the surface may be covered first with transparent adhesive tape allowing the sample to be removed and affixed to a microscope slide.

This device will overload after two or three hours, so for a 24-hour sample the rotorod unit should have a step-timer to cause the rod to rotate intermittently. To prevent impingement of pollen on the rod while stationary, we have equipped each of our samplers with a hood to automatically expose the rod while rotating and cover it while idle. As with all pollen samplers, it requires a rain shield for operation in wet weather. The cost of such a machine is moderate and the conversion of data to a volumetric basis should be acceptably accurate. It requires electric power. 12 rotorod units can be assembled with a step-timer to take 24 one-hour samples each day. Each rotorod rotates clockwise for an hour and counterclockwise for another hour, thus collecting samples on all four faces. Our latest model has the units on a continuous belt which exposes only one rotorod at a time.

A slight modification of the rotorod sampler by experimenters at the University of Michigan is called the roto-bar sampler. (Harrington, Gill and Warr 1959). We are now experimenting with a modified version, the rotoslide sampler, taking the samples on the edge of removable microscope slides that are counted as are those of the slide-edge-cylinder.

Volumetric Samplers

Several devices are available for sampling measured air which may be drawn into the sampler by some means, such as a vacuum pump. Tests may indicate high efficiency in catching the pollen that enters the machine but we cannot assume that the sample gives an accurate indication of the pollen concentration in the outside air. Unless the intake opening is continuously oriented into the wind and the air flow through the sampler is equal at all times to the wind speed in the free air approaching the intake, the system is subject to the serious errors of anisokinetic sampling. Samplers drawing air through an aperture are not recommended for conditions of variable wind speeds unless the diameter of the particles is under 5 microns. Ragweed pollen is approximately 20 microns.

Samplers employing molecular membrane filters have the advantage of retaining pollen on the filter surface where it may be viewed under a microscope but the heavy pollen grains may not faithfully follow the air stream as its velocity is modified upon approaching the filter. The number of grains per unit volume of measured air may be several times more or less than the actual number in the same volume of outside air. A timer makes possible the automatic taking of successive filter samples (Raynor 1957).

Several recently designed devices indicate the variation in pollen concentration during the day. The Hirst Spore Trap (Hirst 1952) draws measured air through an orifice oriented into the wind. The pollen is impacted on a microscope slide moved across the orifice at two millimeters, per hour by a clock mechanism. A continuous trace of the day's sample is deposited on an area 14 x 48 mm. This sampler was designed primarily for fungus spores much smaller than ragweed pollen and for its intended purpose its accuracy is high. For particles in the size range of ragweed pollen it is subject to the errors of anisokinetic sampling, although the orifice is streamlined and the flow rate chosen to minimise this effect.

The Marx Impinger (Marx, Spiegelman and Blumstein 1959) draws measured air onto a disk that makes one revolution in 24 hours. The disk is graduated to indicate the time of day and a special holder makes microscopic examination rather easy.

Special Sampling

Certain extraordinary requirements may have to be met for some types of sampling experiments. An example would be a study of the dispersion of ragweed pollen from a known source. To distinguish such pollen from that from other sources it might be desirable to tag the grains with something readily detected. One method is to label the grains with some radioisotope, as radiosulfur (S35) or radiophosphorus (P32). We prefer radiosulfur which we introduce in such way that it is taken into the plant and transported to the pollen grains which are later shed in the usual way. The amount of radiation in each grain is too small and too variable for the pollen to be properly counted with radiation measuring devices. However, autoradiographs furnish a satisfactory method. These cannot be made easily from samples on a greasy medium so some other sticky substance is necessary, such as dilute rubber cement. The glass microscope slide, with the pollen grains adhering to the cement, is dipped into a heated liquid nuclear-track photographic emulsion, dried and stored for a few days or weeks, and processed in much the usual way for photographic plates. The atomic explosions appear as black traces radiating from the labeled grains. Such slides are stained and studied in the usual way.

An easier method exists if our study of the travels of ragweed pollen can be made at a time when no other ragweed pollen is in the air. Ragweeds can be grown to shed their pollen a few weeks before the regular ragweed pollen season. Being day-length plants, increasing the period of darkness for a few days with a suitable hood (e.g. light-tight cloth) will initiate flower formation. Actually, this is not necessary for we have found that the giant ragweed (*Ambrosia trifida*), started in the greenhouse from seed planted early in April, transferred to 5-inch pots in May and allowed to become root-bound before transplanting in the field early in June, will shed pollen during late July. This allows us to make pre-seasonal dispersion studies from a known source.

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INTERIM REPORT ON AQUATIC WEED CONTROL OF RECREATIONAL WATERS ABOVE POTABLE WATER

Dean C. Noll [1] and Robert Budrick [2]

The Passaic River above Little Falls, N. J. drains an area of 750 square miles. On this drainage area are located the water supplies of much of metropolitan New Jersey. These include the Passaic Valley Water Commission, City of Newark, Jersey City and North Jersey District Water Supply Commission which can supply a combined total of 340 m.g.d. The treatment of these waters is limited to simple chlorination, with the exception of Passaic Valley Water Commission which has facilities for sedimentation and filtration.

Also located on this watershed are the recreational lakes of metropolitan New Jersey. This drainage area has been generously endowed with lakes, ponds and streams. Some of these lakes are deep natural bodies of water while others were created by damming up streams and flooding swamps and meadows. The 120 square mile Rockaway River watershed, supplying Jersey City, has a difference in elevation from headwaters to overflow at the reservoir, of 1100 feet. This gives a rapid runoff and any change in the quality of water is noted in a very short time. The 94 square mile Wanaque River drainage area has nearly 40 recreational lakes which overflow into the 29½ billion gallon reservoir operated by the North Jersey District Water Supply Commission.

Thirty years ago this area was sparsely inhabited but with the advent of the automobile and better highways the land became a real estate agent's dream. In the decade following the 1950 census there has been a 100% increase in population on this watershed, with the vast majority dwelling there the year around.

Today it seems that everyone wants lakefront property and this has spurred developers to create new lakes, and for the most part shallow lakes, lakes over former swamps and bogs. These shallow ponds with warm water temperatures and fertile bottoms are ideal breeding places for aquatic weeds much to the disgust of the lakefront dweller. He can't swim in the lake that looked so inviting last winter when he bought

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his house. He can't pull a fishing line or row a boat through the weed masses. He sees his property declining in value. Little does he realize that he may have contributed to the problem himself by heavily dosing his lawn with chemical fertilizers and having his sprinkling leach them into the lake to provide more nutrients for the weeds.

He decides to cut the weeds. This works out fine until he tries to haul out these water saturated weeds. He then turns to the chemical manufacturers. After all, if they can provide chemicals to keep his lawn weed free they must have something to help his lake.

At this point the water purveyor whose reservoir is just downstream steps in. His network of inspectors has told him that Lake X intends to chemically treat the water for weed control purposes.

The water purveyor's primary responsibility is to his consumers and that responsibility is to continually provide them with water free from disease-producing bacteria, water free from noxious taste and odors, water as esthetically pleasing as is economically possible. In most cases there is only a single source of water and if this goes bad he may be unable to meet the demands his customers place upon him. Therefore, the New Jersey State Department of Health has backed him up with state laws, including Title 58, which prohibits the introduction of any polluting matter into waters above the point at which water for potable purposes is obtained.

Polluting matter is anything which will render the water unfit to drink, either from a bacteriological, chemical or physical standpoint.

Therefore, the water purveyor must be conservative. He cannot take a chance or gamble that any chemical introduced above his intake will or will not cause him problems, problems from tastes and odors, problems from an undesirable chemical build-up, or problems from a bacteriological standpoint.

Two years ago the North Jersey District Water Supply Commission received its first application to treat aquatic weeds with chemicals. The lake in question had a surface area of 80 acres and the overflow was less than a mile above the reservoir. The chemical proposed for use was Sodium Arsenite. Rather than refuse the use of this chemical without a full hearing a meeting was requested by the water purveyor with the lake owners and the New Jersey State Department of Health. The pros and cons of the question were present and the final result was that the use of sodium arsenite was deemed incompatible with the supplying of potable water; if not from a chemical standpoint certainly from a standpoint of consumer public relations.

The water purveyor has a deep appreciation of the problems of the lake owner and desires to work with him. Since it is desirable and necessary to maintain good public relations with our neighbors on the watershed as well as our consumers an attempt was made to gain additional information on other chemicals available for control of aquatic weeds.

The manufacturers supplied samples of various chemicals so simple taste and odor tests could be run. However, the problem proved much larger and more time consuming than could be handled individually. At this point the State Department of Health was requested to call a conference of the surface water purveyors of the state, the chemical manufacturers and any other interested parties in an attempt to establish a united policy for all to follow. At the conclusion of an afternoon of hearings a committee was formed encompassing members of each group to study the problems. It was felt that more field work was desirable and necessary but this was costly from a chemical standpoint.

However, an ideal situation presented itself. A lake-owner's association applied to a water purveyor for permission to treat with Silvex two lakes which overflowed into a reservoir for potable water. The State Department of Health was contacted and after a series of conferences between the lake-owners, the State Department of Health and the water purveyors, it was decided to permit treatment of the upper lake with 2 p.p.m. of Silvex and use the lake as an experimental ground to study the effects of the chemical on the quality of the water. Samples were to be collected by the State Department of Health, the interested water purveyors and the manufacturer's representatives.

Aerial photographs to scale were obtained from the U. S. Department of Agriculture and a survey of both lakes was made to determine depths and accurately compute volumes. The upper lake had a surface area of 57 acres and an average depth of 8.4 feet, much deeper than the average man-made lakes in N.J. The weed most prevalent was water milfoil.

The surface of the lake was lowered one foot below the spillway and this accomplished a number of purposes. First, it lessened the volume of water to be treated thus effecting a monetary saving to the lake owners by decreasing the amount of chemical used. This, too, was beneficial from the water purveyor's standpoint. Second, it provided a longer detention time prior to the water's ultimate entry into the reservoir and thus gave time for disipation of the odors and tastes from the Silvex carrier. Third, short circuiting of the incoming stream was prevented since there was no outlet.

Samples were collected prior to treatment for analysis for temperature, odor, color, turbidity and pH. The lake was divided into two sections and treatment was made by an experienced applicator. A mixture of Silvex and water was sprayed over the surface of the lake from a boom behind an outboard motor barge. It was introduced at a rate to give a concentration of 2 p.p.m. active material in the area covered.

Samples were collected at the time of application, one day; 1, 2, 3 and 4 weeks after application, to observe any change in the physical characteristics of the water; that is color, turbidity, and odors. The State Department of Health collected samples for phenol determination and samples were collected to see if there would be a bacteriological build-up.

The average color, before treatment, was 24 p.p.m. Four hours after treatment this had dropped to 14, then stabilized near 20 for the remainder of the samples collected. All samples were taken from approximately one foot beneath the surface.

The average turbidity, before treatment, was 3 p.p.m., and this rose to a high of 6 one day after the application and returned to 3 seven days later.

The threshhold odor of the heated water was 1 before treatment and it had an earthy musty characteristic. During treatment this rose to a high of 60, with a kerosene characteristic due to the carrier. This fell to 25 one day later and further dropped to 8 with a musty kerosene odor predominate after one week. Three weeks later the odor was down to 3 and had a musty earthy or vegetable musty characteristic.

The pH was 9.1, before treatment, and dropped to 6.8 after treatment, which is understandable since an acid is being added to the water. The physical results were much the same for the second half, which was treated one week later. After the second treatment it was noticed that a number of very large and very small fish were dying. Samples of the fish were frozen and sent to a laboratory to try to determine whether the cause of death was due to oxygen depletion or chemical poisoning.

One of the primary concerns of the water purveyor is the introduction of any phenol compound into his supply since phenol concentrations as low as 3 parts per billion can cause taste and odor problems. The absence of phenols was indicated in the tests conducted in two of the laboratories using the same method of analysis, while a third laboratory using a different method of analysis found phenols present in some of the samples. Other investigators have reported similar discrepancies, having used various methods of analysis. It is strongly recommended that a standard procedure be developed which can be relied upon for an accurate result.

In the bacteriological analyses it was noted that after an application of the herbicide, the bacterial count as well as the number of coliforms increased and then gradually decreased in the ensuing weeks. Discussions with other analysts indicated that similar results were obtained on other treated lakes, several theories were advanced, but little value or no conclusion can be attached to them. Some interest in this phenomena was shown by micro-biologists and when the opportunity of a similar condition presents itself, a more thorough and comprehensive analysis will be made.

After studying the results of the analyses and prior to having the phenol determinations from the third laboratory, permission was granted to treat the lower lake which overflows directly into the water-supply reservoir.

This lower lake was smaller, having an area of 33 acres, and an average depth of 4.6 feet. It was much more heavily infested with weeds with milfoil again predominating, but with considerable potomogetian robinsii.

In view of the fish kill experienced on the upper lake the property owner's request called for a dosage of only 1 p.p.m. and this lake, though smaller, was to be treated in 3 sections with a longer delay between treatments. In spite of the decreased dosage a very satisfactory weed kill was accomplished.

The sampling program established for this lake was increased to include daily samples for dissolved oxygen determination. The reason for this was to try to establish a relationship between the time after dosage and the dissolved oxygen concentration to see if the absence of oxygen could have been a factor in the fish kill.

In each section treated, after the dissolved oxygen began decreasing the results were upset by rainfall which increased the dissolved oxygen content. However, there was no kill of fish in this lake.

In spite of the reduced Silvex concentration and the heavier weed growth the physical properties of the water; color, turbidity and odor, remained nearly the same as that experienced in the upper lake.

CONCLUSIONS

The conclusions which may be drawn from this experimental work are:

1. The surface of the lake should be drawn down below the spillway a sufficient amount to give a month's detention time before refilling. By knowing the size of the watershed above the lake, the normal runoff per square mile for a particular season and the long range weather outlook, it is possible to make an accurate prediction. It is necessary to insure a month's time before overflow since it was found that odors from the vehicle in which the weedicide is dissolved can persist for as long as 3 weeks.

2. Experienced applicators are necessary, therefore the state should institute a program to examine and license qualified applicants. From the water purveyor's standpoint the applicator should be responsible for advising the lake owner that he is located on a potable watershed and, therefore, permissions must be secured before treatment can be started. He must be capable of adding chemicals to obtain given concentrations from area and depth maps prepared by him or acceptable to him.

3. The lake must be divided into a number of sections for treatment to safeguard against possible fish kill. The number will be dependent upon the size of the lake and the density of the weeds.

4. The chemical manufacturers must take a more active part in experimental work to show that their chemicals will not contribute to the degradation of the quality of potable waters. The water purveyor is willing to cooperate but he is not equipped to perform the necessary laboratory work required to check each and every chemical offered for weed control purposes. Today the manufacturer checks the toxicity of some weedicides. Let him increase these tests to include the detrimental effects on the physical, bacteriological and chemical properties of the water. This will enable the water purveyor to select the chemical which would be the least deleterious to his particular supply. It will also enable the State Department of Health to prepare a list of acceptable chemicals for use on watersheds for potable waters.

AQUATIC WEED CONTROL ON RECREATIONAL AND POTABLE WATER SUPPLIES

John S. Grim [1]

As the name of this paper implies, water in any watershed can be used for various purposes. Sometimes, however, the use of the water entails conflicts as to the protection or treatment of the water in maintaining a standard of purity. In other words, there is a competition for the use of the water. This competition is going to become more keen as water supplies continue more or less static while the demand for water increases.

When one first thinks about this situation, the outlook for the use of chemicals in the water for aquatic weed control tends to be very discouraging. However, as we think back over the history of man and especially the history of the United States, we can find considerable encouragement. The citizens of this country have been faced with many large problems in the past and have solved them. For example - farming in wooded, Indian-filled wilderness, developing farm machinery to do the job of tedious hand labor, developments in the field of engineering such as air-craft, jet propulsion, radio, electronics, etc.

All of these accomplishments involved conflicts between man and nature and a competition among men to solve the problems. The results of the conflicts and competitions have been beneficial in the end to man in general, and to the competitors who were involved. It is a basic truth that those who compete for a prize can improve themselves or their products in the process of this competition. Even the high school athlete, for example, who never has won a race, has developed considerable muscle and perseverence in the process and is thus improved over his pre-competition status.

The desire among men to obtain a prize or some other award is one of the strongest motivating factors for action known. It is one of the most important factors contributing to the growth of the United States today into one of the major countries in the world. This is also the country with the highest standard of living in the world. Let us keep this in mind and as we approach the problem of weed control, let us realize that there is a great deal of value in the competition involved in searching for the solution to our problem.

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We are facing today a competition between household uses and recreational uses (among others) for the available freshwater supplies. The competition between these two uses is especially acute, for the water to be used for recreational purposes must be utilized in its natural state as it is contained in ponds, lakes, and streams. This situation is further complicated because the use of the water for recreational purposes usually precedes its use as drinking water. At least when that sequence occurs, the competition is greatest because recreational uses can cause the water to become less pure relative to drinking water standards. In many watersheds the use of the water for recreational needs involves first clearing the water of obnoxious weed growth through the use of chemical weedicides that are retained in the water for a period of time before they detoxify or precipitate. Such a situation causes considerable concern among those people who are charged with the job of supplying drinking water to a human population. That, of course, is how it should be. We certainly would not want our water supply personnel to be oblivious to the dangers of a polluted water supply.

The protective concern relative to water purity on the part of these people can be so strong, however, that they wish to set up a priority system of water use. By priority system is meant that the use of the water is reserved solely for potable purposes. All other purposes being forbidden or greatly limited.

This attitude is definitely opposed to a "multiple-use" program of water utilization. A priority system is undesirable because it inhibits progress in the search to find materials and methods whereby aquatic weeds can be controlled without harm to the water supply. This is so for the following reasons:

Since freshwater supplies are limited by the amount of rainfall, and the need for fresh water rises with the growth of the population and the economy, we can reach a time with a priority system when nearly all of the fresh waters will be used and reserved for drinking supply only. (Some authorities have already set a date in the not-too-distant future when fresh water demands will exceed the present supply.) In other words, there will be only limited areas where recreational activity and the use of chemical weedicides will be allowed. The consequence of having only a limited area where weedicides might be used is a limited market. But, no company can afford to do research and testing of a product which will supply only a limited market, and the search for better aquatic weedicides will come practically to a halt. Competition to supply a large market, on the other hand, can speed up the search to find aquatic weed controls that are not detrimental to potable water supplies.

Many other products also used in and on our natural water supplies can suffer a decline in sales because of a priority use policy.

For example:

Imagine, if you can, that all of the water in a large area such as the State of New York or even the entire United States has been set aside largely for potable water uses and is regulated so that people can fish only from shore or from boats without motors, that no cottages may be built, no swimming allowed, and the area is fenced and posted in many places so that hunting and other similar activities cannot take place. (Some water supply authorities are presently as stringent as this, in their control measures.) In this area the money formerly spent for boating, swimming, hunting, vacationing, etc. is no longer so spent.

Let us assume now that a "multiple-use" policy is initiated in a watershed so that aquatic weed control with chemical herbicides can be practiced. One then may ask what the effect upon water standards will be? Water standard regulations in the most zealously guarded watersheds will be liberalized. This does not necessarily mean that the water quality itself at the point of draw-off will be less, but that the use of the water will be extended. In some cases, one might even expect lower tolerance levels to be established to accommodate users who wish to treat with chemical weedicides. Under no conditions, however, should standards be reduced to a level that would render the water dangerous for human consumption just to please a person or group interested in using a chemical weedicide.

It is expected, too, that standards will vary with the distance from the pumping station of the supply system. Recreational uses can be expected to be more extensive at points most distant from where the water is ultimately drawn for drinking use. This, of course, is true now to some extent.

In time, an improvement in water quality can actually be expected in connection with the use of chemical weedicides in potable watersheds. As various manufacturers compete for the weedicide market, they will be constantly striving to produce a more efficient, saleable product. That, of necessity, means a product less dangerous to man. Here again, competition acts to benefit those interested in both weed control and drinking water.

An example of this was recently brought to my attention where a 2,4-D formulation was releasing phenol compounds in the water. These compounds were unwanted by those interested in the supply as potable water. The 2,4-D complex was changed and the formulation altered in such a way that the release of phenol was stopped.

We see this competition at work again in the various testing programs being reported at this Weed Conference. I note with interest that papers are being given on the use of two fairly new aquatic herbicides in the Aquatic Section. In fact, the demand for and the interest in aquatic herbicides was the cause for the starting of the Aquatic Section several years ago.

An additional factor where competition is aiding in the program to improve aquatic weed control, and tends to keep the water quality higher in potable watersheds, is in the spray operation itself. The increased demand for weed control has interested the custom spray operator. The professional spray man is acquainted with spray equipment and can give efficient, cabeful service. He is less likely to make errors in dosage and in application that could endanger the water supply than is a non-professional pond owner. In addition, as demand for the work increases, the spray operators compete with each other for the price of their services and for the efficiency of their control.

They are also placing pressure upon manufacturers of weedicides to come up with better products than they presently have. The result is more efficient weed control.

Some state governments now recognize the fact that a spray operator can be a beneficial factor in the control of aquatic weeds without endangering water quality. To further guarantee that water quality standards will be observed, however, these states require that all custom sprayers using aquatic weedicides be approved before they work in any of the state's waters.

The value of the approved custom spray man who operates in a potable water supply cannot be minimized for two reasons: 1. They get around and are constantly making contact with those who are suffering from weed problems. 2. They are informed as to weedicides and their use.

The many stories that reach me relative to fish kills and unwise applications of aquatic weedicides invariably repeat the story of the person, who, wanting to kill weeds, merely threw in some particular chemical for that purpose. Instructions are not read or fully read, calculations as to water volume are ignored and other factors of water quality are ignored which have a bearing upon the toxicity of the material used.

It is in connection with the custom spray man that I wish to bring up the next point in this paper and that is the type of control system used to protect a watershed. The control system would, of course, take into consideration that the water is being used both for recreational and potable needs. It is not the scope of this paper to examine various means of control, other than to say that a system of control for any kind of a watershed involving multiple-use of a water supply, would not leave out the possibility that some of the work can be done by approved custom spray men, and the competition involved will be to the benefit of those both using the water and protecting the water. Such a program would allow for considerable freedom of movement by the individual, and the concentration of regulatory responsibility would be placed in the individual as much or more than in the state or other higher echelons of government. (It would be a system without need of extensive permits and pre-treatment checking by government personnel - all of which is costly, cumbersome and encroaches upon individual freedom.)

CONCLUSION:

In conclusion, I would like to emphasize one other related and important thought that we should keep in mind while drawing up water standard regulations.

We are not only biologists and civil servents, but we are citizens of the United States at a time when forces are trying to seize power throughout the world, especially in this country. The power cannot be seized unless it is first concentrated. We must guard against the concentration of any more power than is absolutely necessary in our governmental set-up.

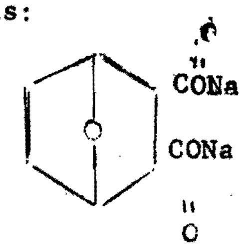
This was a lesson learned by the early colonists and led to the Declaration of Independence, the American Revolution and the Constitution of the United States. The American Constitution is unique in its pattern of organizing a system of checks and balances. so no branch of government is all powerful.

It can be seen, then, that a problem involving the water in a watershed both for potable and recreational uses is expanded into several fields or phases of our life, not only economical and recreational but even political. It is a wise and far-seeing group who can take into consideration all of these aspects while endeavoring to solve its own specific problems.

CONSIDERATIONS REGARDING THE USE OF AQUATHOL IN POTABLE WATER SHEDS

H. L. Lindaberry

The first consideration is -- what is Aquathol? As many of you in attendance here may not follow aquatic weed control closely, I will try to give you a brief background. Aquathol is the trade name for an organic contact herbicide. The active ingredient in this product is the disodium salt of 3,6 endoxohexahydrophthalic acid, more commonly referred to as disodium endothal. Aquathol was developed for the control of various submerged and emergent aquatic weeds as well as for certain algae. The structural formula for disodium endothal is:



The word endothal alone is the common term applied to the 3,6 endoxohexahydrophthalic acid.

Disodium endothal is soluble in water to the extent of about 25% and also it is insoluble in most organic solvents. It is currently commercially available for use on red beets, sugar beets, spinach, turf, and for harvest aid uses, in addition to aquatic weed control. The two principle formulations commercially available for aquatics are the 2 lb. per gal. water solution of disodium endothal, sold under the trade name, Aquathol, and the 5% granular product impregnated on 8-16 mesh attapulgite clay, available as Aquathol G.

The next consideration is -- why use Aquathol? Summarized, the reasons are:

1. Gives good control of many aquatic weeds.
2. Rapid disappearance.
3. Wide margin of safety to fish and other aquatic fauna.
4. Low chronic level of toxicity.
5. Relative safety to the applicator (if directions on label are followed.)
6. Economy.

To go into detail on the reasons that I have just summarized, first of all, Aquathol controls many of the major aquatic weed problems found in the Eastern and Central United States. It is particularly effective against most potamogeton species, as well as milfoil, coontail, waterstar grass, Naias, duckweed, zannichellia, burrweed, and wild celery. As for algae control, good knockdown, especially on floating mats can generally be obtained, but in some instances where favorable conditions have been present, regrowth has been a problem, due to the short residual action of disodium endothal.

With reference to the second point, namely, short residual action, extensive tests have shown that the disodium endothal initially applied to the water in the field rapidly disappears. In tests where Aquathol is applied at 5 ppm of the active ingredient, residue has been shown to completely disappear in four days. In the tests at 10 ppm (five times the rate that would normally be used on an overall treatment basis), the residue was shown to also completely disappear in four days; at one ppm, the residue was gone in about 72 hours (3 days). When one considers that the normal overall treatments will be in the range of one to two ppm, then one can realize one of the major advantages for using such a material.

There is considerable evidence to indicate that the breakdown of the disodium endothal molecule is due to biological action. Due to the fact that there are no heavy metals involved in the molecule build-up in the bottom mud or in the water is not possible. Current recommendations are that the water not be used for domestic purposes for 7 days following treatment. Tests regarding fish residue were run using radioactive disodium endothal on goldfish at 6.0 and 12.0 ppm, and salmon at 2.5 and 5.0 ppm, by Dr. Virgil Freed, Oregon State College, and Dr. Illo Gauditz of Pennsalt. Rather than go into detail, the results could be summarized, that no significant endothal residue was present in the fish used in the test even at the highest rates.

Another possible aspect of concern with respect to residue, is possible build up in resistant plants. As Anacharis (or Elodea as it is now called) is resistant to disodium endothal, this weed was selected. Dr. Virgil Freed and Dr. Gauditz conducted studies with the radioactive disodium endothal on this species. Conclusions from this work are summarized that disodium endothal is not likely to accumulate in aquatic plants. (Dr. Freed is giving a paper at this NEWCC concerning techniques involved in these studies, and I hope that those interested will attend).

Regarding consideration three, with respect to fish toxicity in laboratory tests, blue gills have been able to tolerate over 100 ppm for 21 days (when the tests were discontinued). Likewise, no mortality of three species of minnows, Redfin (Notropis umbratilis), Red Shiner (Notropis lutrensis), and Bluntnose (Pimephales notatus), was indicated at 40 ppm (the highest dosage tested). Likewise, salmon, rainbow trout, and bass, showed no mortality at 10 ppm (the highest dosage tested). It is apparent, therefore, that with normal use dosages of 1-2 ppm, there is a wide margin of safety between control level and fish toxicity. Regarding field studies, no fish mortalities have been noted in field tests to date after applying Aquathol.

One thing to bring out here, however, is that Aquathol is a contact weed killer. Under conditions of heavy weed growth, the user must take care to treat only portions of the pond or lake in order to prevent kill of fish from oxygen depletion due to decaying vegetation. This would be the case where a high dosage was used on a particularly susceptible weed. With respect to toxicity to bottom fauna, tests indicated no significant changes in populations of various species of aquatic worms, clams, and various aquatic insects, either shortly after treatment (one week) or six weeks after treatment. This would certainly indicate that Aquathol would not adversely affect the fish population by effecting certain aquatic species either directly effecting the fish or their food chain. Therefore, in areas where fish management is a major consideration, this point should be taken into account.

Consideration number four, with respect to chronic toxicity:

1. A two-year chronic study in rats, indicated that at 100, 300, 1000 ppm of disodium endothal in the diet, there was no significant difference in the survival of the rats or any indications of intoxication at the above dosages.

2. There was no statistically significant difference in the weights; however, rats feeding on 1000 ppm of disodium endothal in the diet showed a lower weight.

Here, I feel that it would be well to go back and review the normal use dosage which is normally required for control on an overall aquatic treatment. This would be 1 to 2 ppm in the water. This foregoing, coupled with the short residue picture of 48 to 76 hours at 1 to 2 ppm in water, and even at the maximum dosage of 5 ppm a complete residue disappearance in four days, would indicate a good safety factor.

The next consideration is with respect to the toxicity to the user and handler. Aquathol is certainly safer to use than some of the other materials currently used for aquatic weed control, and other herbicidal and insecticidal uses. In toxicity tests on rats the oral LD_{50} for Aquathol (19.2% solution of disodium endothal) was found to be approximately 200 mg/kg. of body weight. The granular 5% formulation, previously referred to as Aquathol G, would be correspondingly less.

A 1% solution of disodium endothal (10,000 ppm) was irritating to the skin without evidence of sensitization. Higher concentrations increased the degree of skin absorption and toxicity. Under normal recommended precautions for handling Aquathol this product can be used safely. Once the material has been applied, there should be no danger of acute toxicity to either humans or animals. Reasonable precautions considered are as follows for Aquathol, as well as all other pesticides:

1. Read label warning.
2. Avoid contact with eye and skin with both concentrate and diluted material as much as possible.
3. Avoid inhaling or breathing dust, granules, or spray.
4. Wash off any material spilled, or otherwise applied on your person, as soon as possible.

5. Don't smoke, drink, or eat while you are applying the material and wash before doing so.
6. Bathe and change clothes at least daily while using.

Regarding economy of treatment using an average depth figure of 4 feet, the average cost of Aquathol for a 1 ppm. treatment of disodium endothal equivalent would be about $35.00 per acre.

The treatment may run more or less, depending on the species involved.

To sum up the considerations discussed, the points to be taken into consideration are as follows:

1. Aquathol's effectiveness.
2. Aquathol's rapid disappearance.
3. Wide margin of safety to fish and other fauna.
4. Low chronic level of toxicity.
5. Relative safety to applicator.
6. Economy of use.

CHEMICAL CONTROL OF AQUATIC VEGETATION IN RELATION TO THE CONSERVATION OF FISH AND WILDLIFE

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In 1959 the New York Water Pollution Control Board issued permits for chemical control of vegetation for more than 1900 acres of water, distributed over lakes and ponds with a combined acreage of nearly 15,000 acres. This represents only part of the water area treated in this State, since the regulations exclude from the necessity of obtaining a permit water supply agencies treating their sources of supply and parties treating ponds with no outlet which lie within the lands of a single owner. It is also suspected that many waters are being treated in ignorance of the necessity to obtain a permit. These permits were issued for the treatment of marginal areas only, since the available information was inadequate for the evaluation of the primary and secondary effects on aquatic resources. A great deal of research is necessary on the effects of chemical methods in order that they may be used to increase the recreational value of waters with the minimum of adverse effect on fish and wildlife. Uncontrolled use to remove <u>all</u> vegetation from waters is ill-advised and can create a grave pressure against our already dwindling aquatic resources of fish and wildlife.

<u>Importance of vegetation</u>:

The dependence of animal life on plants is just as great in water as on land, possibly even greater. In the absence of rooted aquatics, algae, diatoms and bacteria, the existence of fish and the forms on which they feed would be impossible. No one would consider destroying all vegetation and then turning in stock to feed, yet too often that is attempted in aquatic pastures. It is fortunate that many of the chemicals now in use are not too highly efficient.

During the Allegheny-Chemung Biological Survey (1937) a comprehensive study was made of the bottom food in a bay of Chautauqua Lake. On a line extending lakeward, the number and extent of the weedbeds were plotted and the plants composing them identified. In the shallow water zone (0 to 6 foot depth), seven weedbeds and seven weedless areas were found to cover a distance of about 97 meters. The quantitative average of the food present in each area has been multiplied by its extent, added, and divided by the distance covered in meters. This gives the average production in each category. The weedless area averaged 32.3 g/m^2 (grams per square meter), while the weeded sections averaged 169.2 g/m^2. The weeded areas thus contained 5.23 times the food organisms available in the weedless areas. Based on the comparative dimensions of the areas and assuming that production in the weedless zones would be uniform on removal of weeds, it can be computed that the presence of weeds increased the food 4.3 times what it would have been in their absence. More than one-half of the 61 species present were restricted to weedbeds, while only a few species were restricted to weedless bottom.

Studies in deeper waters showed less variation between weedbed and weedless zones. In part this is due to the presence of fewer stems in deep beds and in part, to the presence of large burrowing forms in the open bottom which increased the weight though not the availability as food for most fishes.

Since the extreme richness and productivity of Chautauqua Lake is not typical of average waters of the State, these results may not be capable of extension to all waters. Quantitative studies were also made on 10 bays, ponds and reservoirs in the Lake Ontario Biological Survey (1939). Seven of these contained weedbeds. There was no accurate measurement of the extent of these beds so computation cannot be made on the same basis as with Chautauqua. Individually, the food in weedbeds ranged from 0.7 times higher than in weedless areas in a bay in which no shallow water beds were present, to 22.8 times in a bay too shallow for the development of a typical deep-water fauna. The average food content in the weedless sections of these waters was 7.8 g/m^2, while the weedbeds, including both deep and shallow areas, was 21.9 g/m^2, or a 2.8 times increase in food organisms over the weedless zones. In the waters without weeds, food ranged from 1.8 to 7.6 g/m^2 for an average of 3.8 g/m^2. Except that these included two reservoirs where the establishment of weeds was prevented by fluctuation, it could be argued that the absence of weeds indicated low fertility, hence, low productivity could be anticipated. The reservoirs averaged only 2.65 g/m^2.

A number of species of fish require weedbeds for spawning areas and a few are quite particular as to the depth of the bed. Little information is available on preference for certain plants. Absence of weedy areas would appear to prevent satisfactory spawning of these fishes and the destruction of all weeds in waters in which they are present would lead to their eventual elimination.

The young of both game and forage species require shelter from predation. Many food organisms may be cropped satisfactorily only by small fishes or fish with special feeding mechanisms. High productivity requires utilization of much of the food supply in growth of small fishes. In turn the protein produced is converted to growth of the larger species through predation. Without the shelter provided by weedbeds against predation, opportunity for growth would be reduced and much of the food supply would be poorly utilized. Both forage and predacious species would be reduced and growth would be slow in the latter group. Low production would result and the balance would tend to favor any coarse, rapidly growing species which might be introduced.

On the basis of the above, the desirability of vegetation in waters where the preservation and production of fish and wildlife are important may be readily inferred. Waterfowl are even more dependent upon rooted vegetation than are the fishes. While any removal of weeds will slightly reduce total productivity, it is believed that some vegetation may be removed, or species changes effected, in almost any water without significant damage to aquatic resources. Such removal improves the waters for other recreational purposes and, in some instances, may result in a desirable shift in fish populations although this contention has not yet been supported by any experimental data. The degree of removal that can be permitted and still maintain satisfactory fish production has also not yet been established. Conceivably it will be different in different waters and will also vary with the species present.

Most rich lakes are in a state of dynamic balance in which either rooted aquatics or algae predominate. Except where abruptly sloping bottom or other physical features restrict rooted vegetation to a narrow band, algae is seldom a problem in the presence of rooted growth. Heavy algae production prevents the establishment of weedbeds. Interference with either type of growth can throw the balance in the opposite direction, since the growth depends on the availability of nitrogen, phosphorus and in part on the abundance of calcium. Sources of the fertilizing elements may be either sanitary sewage, or runoff from rich agricultural lands. No control procedure in use attacks the basic problem which is high fertility.

Control Methods:

Formerly, a cottage owner confronted with a weed problem that interfered with bathing in the vicinity of his dock got busy with a rake. The same method was used to open a path through a weedbed to give his boat access to open water. Now his first thought in a similar situation is "Can't some chemical be used for a permanent solution." In part this may be evidence that the population is becoming chemical minded; in part it may stem from the desire to avoid physical exertion, but it is largely due to widespread advertisement of chemical methods.

Chemicals used in vegetation control can be defined either as 'shotgun' or specific. In other words they can readily control nearly all vegetation, or are capable of controlling easily only a few. Frequently a chemical may be made less specific by increasing the dosage. All vegetation is not equally objectionable to a cottage or boat owner and with development of chemicals to cover a range of plant species it should be theoretically possible to remove the objectionable species, leaving the others to fulfill the functions for which they are best suited. Such a procedure would allow the use of the fertility by some form of rooted vegetation and aid in the prevention of nuisance growth of algae that develop all too frequently when extensive weedgrowths are removed by one of the 'shotgun' type chemicals.

Any chemical can be expected to have toxicity to fish and to the organisms on which they feed. Safety requires that the dosage level for weed control be considerably lower than the levels at which the chemicals affect aquatic life. Surber (1931) reported that sodium arsenite equivalent to 1.7 to 2.0 p.p.m. as As_2O_3 will control weed growth in ponds with destruction of the microscopic plant and animal growth on which fish depend for food. This was based on the laboratory studies of Surber and Meehean (1931) on these animals. Lawrence (1958) demonstrated that two 4 p.p.m. applications of sodium arsenite one month apart reduced bottom organisms 34% and bluegill production 42% in the waters he was using. Four p.p.m. killed all micro-crustaceans and reduced the rotifer population. They were not replaced in two months time. Springer (1957) reports othersto have found 2,4-D formulations to have widely varying toxicity to fish ranging from 1 to 100 p.p.m. Some fish food organisms are reported to suffer losses of over 25% at 0.1 to 0.4 p.p.m. Insects are stated to be somewhat more resistant in that 0.4 to 2.0 p.p.m. is needed to cause similar losses. Some fish toxicity has also been reported for 2,4,5-T. Some of the chemicals suggested for weed control have such high toxicity to fishes that their use cannot be permitted in any water where aquatic life and fisheries are of any importance.

Spot treatment in water is in no way similar to spot treatment on land. Currents, rate of solubility and diffusion act to reduce the concentration in the treated area. Hence, efficiency of treatment at a specified dosage varies directly with the size of the area treated. This puts a premium on the treatment of large areas. Dosage is increased in small areas in compensation. Density of stand is infrequently considered yet is probably a definite factor in many unsatisfactory treatments.

In certain locations increased dosage may be advisable for satisfactory control, yet there is a natural reluctance on the part of control agencies to permit it, because of the tendency of the operator to continue such dosage in all areas. No standard method to evaluate the dosage has been devised. Protection of natural resources demands that requests for increased dosage be carefully examined and permitted only when proof is available that it will not be detrimental to the organisms existing in the area.

Research Needs and Procedures for Study of Chemicals in Use:

Study and publication of the effect of these chemicals on the aquatic environment have been entirely inadequate. Mainly they appear to have been restricted to determination of the toxicity level for a few species of fish in a water of unspecified composition and much more intensive work on what concentration will destroy certain species of plants. Any quantitative study of the effect on the organisms in the treatment and contiguous areas is commonly either not made or not reported. Use of pelletized applications results in the release of the highest concentrations on or near the bottom where the effect on food organisms will be greatest. The fact that studies must be conducted on several waters of differing composition can be shown by arsenite, which has been reported to disappear very rapidly in some waters yet was shown to be extremely persistent and the reduction in concentration slow in the only waters studied in New York State (Analyses of the N.Y. Health Dept., unpublished). While conservation and regulatory agencies should have a part in conducting such studies, it must be recognized that the major responsibility should lie with those suggesting and recommending such chemicals for use.

Bio-Assay:

Laboratory bio-assay can be helpful in the evaluation of comparative toxicity of control chemicals to fish and other aquatic organisms. Modifications in procedure are required. Many of these chemicals are not easily analysed in dilute solutions and it is difficult to determine rate of removal by the test organism. Use of double or triple volume solutions will show if the evaluation of toxicity is being affected through removal. Replacement of solution or continuous flow is valid only if the entire test solution is made up at one time as only this modification will correspond with a lake or pond application. Since continuous flow is desirable to maintain a uniform oxygen concentration, the time that these experiments can cover is limited. Results when reported in terms of the initial concentration may not truly represent that concentration as the concentration may vary with time and from reaction with the water or bacterial decomposition. Toxicity curves do not usually conform to those anticipated if fresh solutions of definite composition were to be used. However, bio-assay can be used conveniently for the evaluation of the effects of the character of the water, oxygen content, pH and temperature.

One of our laboratories is testing the comparative toxicity of these chemicals using brown trout fingerlings. While the data is too incomplete for release at this time, the toxicity of certain 2,4-D formulations appears to range from 2.5 p.p.m. to 16 p.p.m. in terms of the acid equivalent. While it is not yet definite whether toxicity is due to the compound, impurities of manufacture, or the vehicle, the compound appears indicated. Differences in behavior of different formulations have also been observed in the field. This may indicate that formulation may be more important than acid equivalency in aquatic reaction. One hormone type chemical increased in toxicity on standing in solution, apparently either due to hydrolysis or some other reaction in the water.

In situ studies:

The very fact that bio-assay is conducted under such carefully controlled conditions may react against its transference as representative of field application. It cannot measure reduction through intake by plants, absorption on bottom muds, or the reaction caused by different bacterial populations. It therefore cannot supplant an in situ study under actual field conditions. Preferably, the area chosen should have at least one season of study before the application even when control areas are established. Qualitative data alone is inadequate and conclusions should be based on quantitative sampling.

Ideally these would cover food organisms, rate of growth of fishes, their abundance and effectiveness of reproduction. As repetition of treatment is usually the case in weed control and the changes in the fauna may be cumulative, the study should be continued for several years. Each report should include a complete analysis of the water and the determination of the weed species present to assist the regulatory agencies in transference of the results to the waters in which they are interested.

Effectiveness of Chemical Control:

Certain chemicals that have been used in New York do not appear to have been too effective. For example, Findley Lake was an exceedingly weedy lake with nearly 3/5 of its area in weedbeds. In 1956 a program of weed control was instituted. Sodium arsenite at a 7½ p.p.m. dosage as As_2O_3 was used and was reported to give good control. The next year the dosage was increased to 10 p.p.m. It was claimed results were slightly better. When it became necessary to obtain a permit, the dosage was cut back to 7½ p.p.m. It was claimed this failed to control the weeds. In 1959 an application was made for the use of pelletized 2,4-D and a dosage of 10 lbs. per acre acid equivalent was authorized since the problem was primarily *Myriophyllum*. It was reported to the Board that the agent would not guarantee results at less than 20 lbs. The permit was amended to permit this dosage provided the area treated was cut in half. Application reportedly failed to achieve results and the weed situation was the worst it had ever been.

It has been reported that low level arsenic may increase weed growth and the same for applications of plant hormones where the concentrations are inadequate to kill the plants. It begins to appear that such treatments may increase growth greatly outside the treatment zone and even inside, after lethal concentrations are dissipated. Increased proliferation of plant tissue could so increase the total volume of tissue that any normal dosage is inadequate for control.

For the past two years the Chautauqua Lake Association has treated extensive areas of the lake with arsenite. In one area, in one year, 2,4-D was used. Complaints are now being received that in the untreated areas the density of the weeds is greater than it had ever been previously.

This poses a question which must be answered. Is spot treatment for weed control increasing the problem in the areas contiguous? Is it possible plants are developing chemical resistance? If either is so, further consideration must be given to the authorization of these chemicals for use where it is considered undesirable to allow complete elimination of weeds.

Public Health Implications:

Possible effects on water supply has received much consideration by health agencies. The matter of possible residuals in the animals and fish living on or in these bodies of water and their effect on public health when used as food by man may require further study. Except for arsenite, little can be found on reported residuals from chemicals now in use. The problem of these residuals appears one that should receive increasing attention in the future programming of these agencies.

Where are we heading in chemical weed control? Unless more detailed information on the secondary as well as primary effects of the many chemicals now available for aquatic weed control are soon available, it appears it may be necessary for the control agencies to further restrict this rapidly expanding operation to assure that irreparable damage does not occur before its possibility is recognized.

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SOME OBSERVATIONS ON AERIAL SPRAYING FOR PINE RELEASE IN EAST TENNESSEE

Thomas K. Goodrich[1]

Aerial spraying of selective herbicides to release an established pine stand, or to weed a pine site in preparation for planting pine, is now an accepted silvicultural practice on many of the larger forest ownerships. This was not always so. Twelve years ago the art and science of aerial application of herbicides was unknown. Six years ago it was in its infancy, only having been attempted experimentally on limited areas. Now, 1961, silvicultural weeding of forest stands by aircraft is coming into its own just as cotton dusting did a number of years ago.

Aerial work appeals to most foresters. They see in it the opportunity to cover large acreages in a short period of time with a greatly reduced labor force. It fits in with the era of mechanization that is filtering through the dimly lit forest aisles.

My company, Hiwassee Land Company, began its aerial spraying program back in July of 1955. Actual negotiations and procedures were worked out with the contractor several months prior to that. The first year's work was not altogether satisfactory, but we believed the technique showed promise. That first year, 1955, we sprayed 2,000 acres of competing low grade hardwoods on the Cumberland plateau. The following year we sprayed 4,078 acres. During the summer of 1957, Hiwassee sprayed 3,635 acres. In 1958, 6,846 acres, in 1959, 7,900 acres, and in 1960, 17,050 acres were aerial sprayed. This totals 41,509 acres. The present year's plans call for another 24,000 acres. So you can see that we think pretty well of this method of silvicultural weeding.

In the course of six years of large scale aerial applications of herbicides, it follows that we are bound to have made some observations that may possibly be of some value to others. Although the hills and mountains of east Tennessee, north Georgia, and north Alabama have presented some difficult problems, these same problems exist elsewhere, and the difference is one of degree rather than character. Any one of the items to be presented in this paper is material for a paper in itself, so, of necessity, coverage is limited.

Organization and Preparation

The organization of a production size aerial spraying operation is of fundamental importance. It can either make or break the entire job. We personally favor the "total contract" approach. Under this

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system the spraying contractor makes us a firm price per acre to furnish a given herbicide and apply it at a specified rate and volume per acre on a previously determined acreage. The contractor furnishes the aerial application, chemical, carrying agents, mixing tanks and equipment, and labor necessary to perform the application. Hiwassee lays out the control lines, furnishes the necessary flagging equipment, flagging personnel, radios, maps and photographs, and transportation for their own personnel. When the contractor arrives on the scene, everything is in readiness to enable him to begin immediately. The control lines have been prepared and staked out, all flagging and radio equipment is at hand, necessary four wheel drive vehicles are present, and the district flagging crews have been alerted for the commencement of operations. Weather permitting, we begin spraying at dawn the day following arrival of the contractor.

Control lines are constructed on two sides of the area to be sprayed perpendicular to the direction of flight. The lines are never more than 3,000 feet apart. If the area is unusually large, it may be necessary to construct one or more interior control lines. Whenever possible, use is made of a road, trail, or utility right-of-way for a control line. Nevertheless, such conveniences are limited and we are thus forced to construct several miles of these control lines each year. The work is done with a D-4 or D-6, the object being to clear a 10 to 20 foot wide opening in the canopy and improve ground conditions to accommodate a four-wheel drive vehicle if at all possible. The bulldozer does nothing more than clear surface obstacles out of the way. No earth cutting or filling is involved.

Beginning with number one, stakes are numbered and driven into the ground along the control lines to indicate the center of each flight swath. The parallel flight lines are 45 feet apart on center. A staff compass, 100 foot tape, and traverse table are necessary for this work, which is field directed by an experienced forester. A slip-up here can sabotage the whole operation when spraying is under way.

Flagging materials so far have consisted of bright colored squares of cloth and helium filled plastic or neoprene balloons attached to the top of 50 foot aluminum poles. Two years ago a limited trial was given a Buffalo turbine dust blower. Last year, balloons constructed of Mylar, a plastic manufactured by General Mills, were used entirely. New developments in this area are badly needed.

In 1959, we tried a "leap-frogging" technique involving the operation of two helicopters simultaneously out of the same helispot. The system works very well as you can normally keep a helicopter in the air continuously. While one is spraying, the other is on the ground reloading. It enables both the contractor and the company to utilize their personnel more efficiently. Should one helicopter develop any mechanical trouble, the second helicopter can continue on alone while the other is being serviced.

Time of Application

In our area of operations we have about six or seven weeks in which to accomplish our aerial spraying. Normally, we can expect to commence operation about the middle of May and to complete the work not later than the end of June, the time varying with the acreage to be treated and the number of helicopters in use. Weather conditions play a vital part in how long may be required to carry out a spraying operation. Winds in excess of five or six miles per hour prohibit spraying. Rain, of course, will bring the work to a standstill. Most all of our spraying is conducted between dawn and 10:00 a.m. and from 5:00 p.m. until dark. With a decent break in the weather, however, one helicopter can spray 1,600 to 2,000 acres in a week.

Personnel Requirements

Our personnel normally consists of two men on each control line, one being a laborer and the other a forester or woods foreman. Each flagging crew is equipped with a mobile or portable radio. Another forester stands by at the helispot to send and receive radio messages from the men on the control lines and direct their movement. The contractor's personnel should consist of a unit supervisor, pilot, mechanic, chemical supply truck operator, and water truck driver.

The entire spraying operation is under the overall direction of a forester from the main office management section, working in cooperation with the contractor and the respective district personnel. He is the liaison between the contractor and our company personnel. He has the authority to make any changes deemed desirable within the framework of the contract, or to halt the operation temporarily or permanently if necessary. Temporary stops are generally due to adverse weather or flagging difficulty. It is to the credit of the capable, conscientious contractors with whom we have worked that permanent cessation of operations during a contract has never been necessary. In the performance of a large aerial spraying operation, there is no substitute for experience. Timing and technique on the part of both the contractor's personnel and the company's personnel is of utmost importance. All must work together as a team.

Equipment Requirements

In the rougher country over which we operate, a helicopter is considerably more adaptable than a fixed-wing plane. Its maneuverability is superior to a fixed-wing plane, and it does not require the landing space of a fixed wing. A helicopter's load capacity does not compare with that of a conventional plane, but it makes up for this in other ways. We have used helicopters exclusively in all of our aerial spraying and are very pleased with their performance. I will say, however, that the more powerful helicopter engines are desirable. Possibly some day we will be able to use helicopters with a load capacity of 100 percent or 200 percent greater than what is now available.

In order that the operation proceed smoothly, the supporting ground equipment must be of sufficient capacity, properly equipped, and mounted on reliable vehicles. Trailers have no place in the mountainous terrain of East Tennessee. Suitable support equipment for one helicopter unit--and by helicopter unit the writer means one or two helicopters operating together out of one helispot--would include the following:

1. One chemical supply truck equipped with two mixing tanks each with a minimum capacity of 750 gallons. Mechanical agitation should be provided by vanes attached to a shaft mounted horizontally in the tanks and powered by a reliable gasoline engine. Metering devices should also be mounted on the truck to enable both parties to the contract to keep an accurate record of all herbicide dispensed. All hoses should be strong, but light in weight and preferably mounted on a reel attached to the truck.

2. One water truck with a tank capacity of at least 1,200 gallons.

3. One pick-up to carry helicopter fuel, supplies, and small parts. This truck is also available to run errands when necessary.

The forester standing by at the helispot has a vehicle which may be used to run any necessary errands.

Agitation

Proper agitation of the herbicide solution is most important to a successful aerial spraying program. It is not sufficient to thoroughly agitate the chemical, oil, and water at the time of mixing. Agitation must be continued at periodic intervals during the spraying operation. In recent years it has been our practice to start the gasoline engine that drives the agitator when the helicopter appears over the tree tops returning to the helispot for another load. Agitation is continued until he is on the ground and reloaded. This is a matter of one to three minutes. Such regular, periodic agitation assures the emulsion will remain homogeneous throughout the mixing tank.

Terrain

Terrain varies considerably in East Tennessee and the adjacent areas. It ranges from flat valleys to gently rolling plateaus to rugged mountains. Elevations on our forest ownership vary from 700 feet to 2,200 feet. Therefore, the ability of the pilot to see our flagging signals often presents a knotty problem. The areas to

... created are usually planned to enable the pilot to fly at right angles to the general direction of ridges or shoulders. Our control lines are then placed on ridge tops or high ground wherever possible. Frequently this necessitates the use of intermittent control lines along several ridge tops. Occasionally a control line may be the edge of a sheer bluff. The pilot must have a strong stomach to be flying at one moment twenty-five feet above the tree tops only to suddenly have the terrain drop beneath him several hundred feet. Having ridden on a few such trips, I can appreciate the sensation.

Application

During the past six years, we have used various formulations, carriers, concentrations, and rates of application. We have used iso-octyl ester, proplyne glycol butyl ether ester, and butoxy ethanol ester. We have used carriers of diesel oil, water, and oil-water emulsions. Our concentrations have varied from 1.5 pounds to 2.0 pounds per acre. The gallonage per acre has ranged from 2.5 gallons to 7.0 gallons. In our area, under conditions such as we have, and considering the species involved, we believe that the proplyne glycol or butoxy ethanol ester at a concentration of 1.5 pounds to 2.0 pounds per acre and a rate of 5.0 gallons of solution per acre, using a 20 percent oil-water emulsion, will give us the desired control at a cost with which we can live. This is not to say that 10.0 gallons per acre would not give us a higher degree of weeding, but that the cost of control would exceed what we presently believe to be the limit.

Nearly all of our aerial spraying has been conducted on areas previously planted to pine. Damage to seedlings has been insignificant. Our effort has been to release all underplanting during the first growing season following planting. Nevertheless, little true release is effected until the second growing season. Therefore, commencing this year we will attempt to spray enough acreage ahead of planting to accommodate our planting budget for the following winter. With this achieved, our planting will benefit from release during the first growing season.

Public Relations

Now I come to a subject that is ever present and extremely important. That is the question of public relations. Thus far I can honestly say that our public relations with adjoining property owners concerning our spraying operations has been generally satisfactory. We have had an occasional instance where the situation has become irritating to all parties concerned, but nonetheless, we have had a negligible amount of strife. And it must continue to be so wherever aerial spraying is conducted or we will all eventually suffer the penalty of restrictive legislation as is now on the law books of some states. On our part, we make it a rule to leave a safety strip between our spraying operations and the adjoining owner. Where cotton, a garden, or an orchard is present we take extra precautions such as a wider safety strip, spraying in a dead calm, or when the breeze is favorable to drift into the spraying area. Even then we sometimes receive a claim. Some of the claims are real and some are imaginary. One must exercise judgement and caution in separating the "wheat from the chaff." When a justified claim arises, prompt and satisfactory settlement by the contractor is the best remedy. Our experience has been that the person with a ligitimate claim is usually the easiest one with which to reach agreement. A fair settlement leaves no hard feelings. This is an obligation which all of us engaged in aerial spraying must shoulder and keep foremost in our minds. No organization, company or contractor, has the right to inflict damage on an individual in achieving its goals.

Summary

Our results have improved each year. As we have gained in knowledge and experience, our silvicultural weeding has more nearly approached the desired control. Thorough organization and preparation are essential to a satisfactory aerial spraying program. Time spent on this portion of the program pays dividends. May 15th to June 30th is the optimum time for foliage application of herbicides in East Tennessee. Personnel must be well-trained in their duties and adequate in number to conduct the job efficiently. Equipment must be reliable and of sufficient capacity to maintain a large scale operation. Proper agitation of the emulsion is of prime importance in achieving the desired control. Terrain often presents difficult and unusual problems. A concentration of 1.5 pounds to 2.0 pounds of 2,4,5-T per acre in a 20% oil-water emulsion at the rate of 5.0 gallons per acre has given satisfactory control. Public relations is a responsibility and problem to be shared by all organizations involved in aerial spraying.

Hiwassee Land Company is looking forward to further progress in the field of aerial application of herbicides. Numerous problems remain to be solved both in the laboratory and in the forest. We stand ready to work with applicators, chemists, physiologists, and other foresters in pushing back the curtains of nescience.

FOLIAR APPLICATION OF 2,4,5-T FOR HARDWOOD CONTROL ON FOREST LAND IN THE ATLANTIC COASTAL PLAIN

Sharon R. Miller[1]

Over the past decade, the use of herbicides has developed into a widely discussed and much publicized tool directed, from the forest management standpoint at least, towards control of undesirable plants on lands suitable for production of more desirable forest products. At first, it took on the common aspect of being an all-purpose process capable of neutralizing or eliminating a host of thorny problems constantly facing forest management personnel. As with most things of this nature, however, limitations and problems soon appeared.

The primary challenge has been to place the use of herbicides in the proper perspective, and determine the many factors governing their successful use in forest management. This activity is in full swing at the present, and is by no means complete. If this were not true, there would be little need for our presence here today. It is quite obvious that meetings such as this, and the host of others that have been held over the past few years, are valuable and necessary to disseminate information and discuss ideas. Prospects for use of herbicides in forestry are encouraging enough, as a result of past work, to warrant attention and due consideration by those individuals and organizations wishing to improve upon and add to present forest management procedures.

Summary of Work in Georgia and South Carolina

Union Bag-Camp Paper Corporation became interested in the use of herbicides in 1956, and, at that time, began exploratory work with foliar sprays for controlling undesirable hardwood species on potentially-valuable pine-productive land in Eastern Georgia and South Carolina. This work was largely predicated upon positive results from large-scale aerial applications of herbicides elsewhere. The need for hardwood control in the southeast was and still is very definite; on many thousands of acres, hardwood brush is holding back established pine seedlings, while on additional thousands of acres, hardwoods have completely taken over. In the first instance, species selectivity is of primary importance in any treatment. The latter condition calls for a herbicide and a treatment technique that will bring about nearly complete eradication of all species preparatory to artificial regeneration of pine.

Our first spraying, in July, 1956, was largely a gamble simply because so little was known about such work at that time. The objectives of this work were both forest type conversion and release of existing pine, depending on the specific area being treated. Hardwoods of all sizes, species, and densities were present on the treated areas, and in some instances, slash or

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loblolly pine existed in quantities large enough to constitute adequate stocking providing they could be released from overtopping and crowding hardwood competition.

All spraying was done by helicopter, with some 2,200 acres of forest land made up of various site conditions being treated. A low-volatile ester form of 2,4,5-T was used with fuel oil as the carrier. The material was applied at the rate of 1.5 pounds of acid equivalent and 2.5 pounds of total solution per acre.

The following summer, July 1957, an additional 3,500 acres of similar forest land were sprayed in much the same manner as in 1956. The primary purpose of treating this additional acreage was to provide a greater selection of conditions for extracting information, and thereby reduce the possibility of obtaining inconclusive or misleading results.

Based upon measured results and periodic observations of effects of the chemical applications in 1956 and 1957, a more intensive program designed primarily along research lines was initiated during the spring and summer of 1958, and this has been continued up to the present time. Small acreages were treated to determine: (1) amount of release, in terms of increased growth, exhibited by young established loblolly and slash pine as a direct result of chemical hardwood control; (2) correlation between degree of pine release and degree of hardwood control achieved; (3) effect of different rates and mixtures of 2,4,5-T upon quality of results; and, (4) usability and effectiveness of ground spraying rigs for chemical application.

Over this total period of time, we have treated a considerable acreage of forest land covering a wide range of conditions, chemical formulations and rates, methods of application, chronological and physiological times of application, and objectives of treatment. Before moving on into specific details concerning recent work on company lands in Virginia, I want to summarize in general terms results of this work in the lower coastal plain of South Carolina and Georgia. Although these results apply directly only to the area in which the data were collected, they are presented for the purpose of adding information that might be of some direct or indirect value to operations elsewhere. It should be emphasized that results to date are by no means entirely conclusive, either silviculturally or statistically. I have made an attempt in the following paragraphs to list and discuss a few of the more important and more definite points extracted so far from these spraying activities. Some are substantiated by data of a quantitative nature, while others are drawn from personal observations and inferences based upon subjective analysis.

1. Type conversion or site preparation using 2,4,5-T does not appear to be a practicable technique for the general area in question. It became apparent early that, although the chemical treatment did considerable damage to hardwoods, this damage was often not in the form of complete kill. Furthermore, when the hardwood overstory was opened up, a heavy ground cover of herbaceous and new woody vegetation developed rapidly, discouraging regeneration measures of any kind without additional mechanical or chemical treatments. Spraying alone just doesn't seem to provide an adequate seedbed for satis-

factory artificial regeneration by direct seeding or planting. In addition, such measures as respraying or spraying and disking seem out of the question for the present because of high costs and the fact that mechanical methods, often combined with prescribed burning, can effectively prepare a site either for planting or reseeding without any spraying.

2. Pine release can be achieved under certain definable conditions using 2,4,5-T as a foliar spray. With very few exceptions, it was found that spraying effects in the form of hardwood damage were obliterated by subsequent new growth and stem resurge within three years after treatment. On areas where a reasonable amount of pine was already established and in a condition to respond to the short term release, chemical hardwood control seemed to be just the thing for permitting the pine to come through. This was especially encouraging since relatively little pine damage was detected as a result of the herbicidal application.

Even where initial damage to pine appeared to be heavy, recovery was swift and complete. No increased incidence of insects or disease was noticed, and pine vigor a year or two after spraying appeared to be excellent. It is still too early to fully measure the absolute amount of pine release in terms of increased growth; general observations and limited measurements, however, reveal a marked increase.

3. Adequate marking of each spray swath is a major problem in both aerial and ground spraying. The only consistent mechanical difficulty encountered concerned the matter of maintaining equidistant parallel swaths. Effective but simple and inexpensive flagging is a necessity that never seemed to be quite fulfilled. Long flag poles and helium-filled polyethylene balloons were both used, with equally frustrating results.

4. Good growing conditions for some time prior to spraying seem desirable, but heavy rains immediately following spraying may adversely affect desired results. Notes were generally taken on average weather conditions prior to spraying, amount of rainfall, and general growing conditions. These rather broad data were used whenever possible to aid in assessing any variation in results that could not be readily attributed to any other factor. The general outcome was that in most cases better growing conditions prior to spraying resulted in better hardwood control. On the other hand, one experience with a heavy rain immediately following spraying indicated the undesirability of this situation. A spraying job in 1958 was followed within a matter of a very few minutes by a heavy rain that measured 0.72 inches. In spite of an unusually high rate of herbicide applied, results were extremely poor. Even sweetgum, which usually is damaged very readily, showed only spotty effects.

5. Susceptibility to damage from 2,4,5-T varies considerably from species to species. The wide variety of species present on the areas treated in this work made it possible to observe and collect quantitative data on the degree of susceptibility of a number of the important and more numerous species.

Using results for all our work, we classified the predominant species into three broad categories. In the first or Susceptible class, we grouped such species as sumac, sweetgum, blackgum, and sassafrass. Since sweetgum appears to react early and consistently, and correlates well with the overall degree of success, the tendency now is to use it as an indicator species. Whenever moderate to poor results are obtained with sweetgum, the spraying in general is usually considered unsatisfactory.

Such species as wax myrtle, dogwood, hickory, sweetbay, and all the oaks except live oak were grouped into the Intermediate class. The last or Resistent class includes live oak, gallberry, red maple, white ash, American holly, and all three major southern pines. It should be noted here that some individual species seemed to vary in susceptibility from treatment to treatment.

From our first two years' work, as an example of overall control obtained in hardwoods, initial measurements indicated that around 60 percent of the hardwood stems were completely defoliated and assumed dead as late as two growing seasons after spraying. Another 30 percent were classified as severely damaged by the spray. On the surface, this appears to be almost complete control, but as noted earlier, new woody growth, stem resurge, crown recovery, and heavy new ground cover had nearly obliterated effects of the treatment by the end of three years. Better hardwood control was generally obtained when straight oil was used as a carrier even though some additional pine damage resulted. Also, best results were obtained when spraying was carried out during the early part of the summer.

6. Some types of ground spraying equipment appear to be as effective for foliar treatment of hardwoods under certain conditions as aerial methods. A small test in Georgia in 1959, designed to compare two methods of ground spraying and aerial application, resulted in successful treatment with a tractor-mounted mist blower in one case and nearly as good hardwood control with helicopter application in another. The other ground treatment, a tractor-drawn high-volume spray rig, did not come up to expectations in several ways. Degree of hardwood control was relatively low, chemical supply problems increased, and difficulties in application were encountered.

It is recognized that the tractor-mounted mist blower has limitations in the form of flagging difficulties, height of vegetation that can be successfully treated, and amount of area that can be covered in a given period of time. By the same token, there appears to be instances where it will be a very useful tool. Small blocks of land, scattered holdings, irregular treatment areas, and small forest ownerships surrounded by agricultural areas all lend themselves more to ground than aerial treatment. Our present plans are to increase such work in the near future for these reasons.

Summary of Recent Work in Virginia

Let me move on now to recent spraying activities on Union Bag-Camp land in Virginia. These were begun on an experimental scale in June of 1959. Our main objective was to test the aerial application of herbicides for hardwood control and loblolly pine release under conditions existing in the southeastern part of the state. It was evident from the beginning that hardwoods constitute even a more prominant segment of forest conditions here than farther south, due, primarily, to generally higher quality sites. The situation is complicated even further by the presence of a high percentage of spray resistent red maple stems in many stands. On the other hand, it is commonly recognized that loblolly pine seedlings are vigorous, aggressive, and persistant when it comes to fighting through hardwood competition. This creates a question concerning selection or recognition of conditions that would economically benefit from brush hardwood control measures.

Due to mechanical difficulties in chemical application, results of the 1959 pine release work lacked the precision and reliability hoped for. The objective generally was to apply, with a helicopter, an oil-water emulsion of 2,4,5-T at the rate of two pounds of 2,4,5-T acid equivalent, two quarts of oil, and four gallons of water per acre. A small area was sprayed with an invert emulsion at the rates of two pounds and four pounds of 2,4,5-T per acre.

Good hardwood control and little pine damage were obtained with the high rate of invert emulsion, but the lower rate was spotty. One area treated with the oil-water emulsion showed poor results while the other may prove satisfactory. So much red maple existed in the latter case that casual observations after treatment indicated little control. Closer inspections, however, revealed large openings where existing loblolly pine seedlings could come through. Pine damage seemed heavy at first, but recovery has been very good.

A second project in 1959 dealt with an effort to find a means for eradicating very dense brush on presently unproductive areas in Dismal Swamp in preparation for some type of artificial regeneration. Several different treatments were applied to test blocks with a helicopter. Combinations of 2,4-D and 2,4,5-T and 2,4,5-T alone were tried at different rates both as invert emulsions and straight fuel oil mixtures. Two treatments provided what presently appears to be extensive but not entirely complete stem kill. Four pounds of 2,4,5-T acid equivalent plus nine gallons of fuel oil per acre gave the best results, followed closely by two pounds 2,4,5-T combined with two pounds 2,4-D acid equivalent in nine gallons of fuel oil per acre. The matter of how to regenerate these areas is still a big question, however.

Our activities during the summer of 1960 were directed entirely towards release of loblolly pine. A demonstration and research project was conducted on a small acreage of company land in cooperation with a distributor of tractor-mounted mist blowers. Approximately 11 acres were sprayed in June using a rate of two pounds of 2,4,5-T acid equivalent per acre in an oil-water emulsion providing five gallons of mixture per acre. This colored slide will give you an idea what the conditions were at the time of spraying. The area had been cut over several years before leaving only loblolly pine seed trees. Sufficient pine regeneration was obtained, but, as you can see, hardwood brush developed also, completely covering most of the pine seedlings. The next slide will give you another look at the area in question, and you will notice that an occasional pine seedling is peeking through the brush canopy. I might mention that there was very little red maple in this area. The primary components were sweetgum and various species of red oak plus some hickory, white oak, dogwood, and black gum.

The next two slides show how the area appeared about three months after spraying with the mist blower. Although amount of actual hardwood kill cannot be readily determined until the summer of 1961, it is obvious from these pictures that good hardwood control was obtained. The surprising thing is that several tall hardwood trees were killed although no effort was made to treat these stems, and there was no wind blowing. Temperature conditions must have caused convection currents which lifted the fine spray into these crowns.

A large amount of pine burn was noted soon after spraying, especially close to the spray lines; most of the defoliated stems immediately began new growth, however, and past experience indicates they will recover. Very few pine stems can be seen in these last two slides due to defoliation. I am sure similar pictures taken at the end of next summer will give a much better impression of this treatment as far as pine recovery is concerned.

In addition to this mist blower work in 1960, 158 acres in similar condition to the small area described previously, were sprayed by helicopter using the same chemical mixture. This is considered semi-operational; consequently, no quantitative measurements are scheduled. It will be used, however, to demonstrate to company personnel just what can be accomplished with aerial spraying. At the present, control results look good but perhaps not as striking as the mist blower work. At the same time, it appears that there was less pine needle burn with this method of application.

One point worth noting concerns the matter of flagging. As I stated earlier, we have always had trouble with this factor. In desperation, I managed to obtain several rubber weather balloons that inflate to about 30 inches in diameter. We filled them with helium and attached them to nylon lines at the end of long bamboo poles. A total height of 50 feet proved sufficient, and they could be easily seen for some distance. This turned out to be the best flagging technique we have used so far. The only difficulty encountered was that repeated applications of spray material on the rubber caused the balloons to deteriorate and burst. We feel that this can be easily solved in the future by covering each balloon with a large polyethylene bag.

As a final item on our spraying work in Virginia during 1960, I want to mention that we tried using the mounted mist blower and a back-pack mist blower to control vegetation along company roads. Results are encouraging but need improvement. It is apparent that a higher rate of chemical application will be necessary here than is commonly used for woods spraying. The ease with which such work can be done, however, warrants further trials of this approach.

Current Work and General Conclusions

In the previous sections, I have covered in very limited detail our work with 2,4,5-T since 1956. Analysis of this activity was almost entirely from the standpoint of kill of hardwoods treated; regrettably, no significant information has been obtained as yet on the highly important second step of evaluation of results in terms of increased forest productivity of the areas treated.

The research results reported here point up the unlikelihood of a sudden spectacular breakthrough to sure, inexpensive, successful, foliar chemical treatments for hardwood brush control. They do, however, strongly indicate the ultimate value of this management tool if used properly, wisely, and realistically. Based upon the work reported herein, we feel that two specific courses need to be pursued. The first is discovery and development of better chemicals and formulations and more effective methods of application of these. Such work is going on by manufacturers and formulators of herbicides and by makers of distributing equipment. The second course of action for research involves evaluation of the effects of such treatment. While such work has been started, it is on a relatively small scale, and is being carried out corollary to the testing of chemicals and methods of applications.

In conclusion, we feel that the use of herbicides has a definite and useful place in our scheme of management. That place is becoming clearer and more specific as experience and knowledge are gained in the use of such chemicals. By no means have all the major problems been solved, and there is still a lot of room for improvement.

HARDWOOD CONTROL WITH MIST BLOWERS

by

William P. MacConnell[1] and Robert S. Bond[2]

Aerial application of herbicides to release conifers has been successful in many parts of the country. Both fixed-wing aircraft and helicopters have been used in this work. Various tests have established spray formulations of 2, 4-D and 2, 4, 5-T that are effective against hardwoods and do little damage to conifers if applied during the proper season. Spray mixtures have ranged from one to three pounds acid equivalent (one quart low volatile propylene glycol butyl ether esters) per acre in varying amounts of fuel oil or water, or fuel oil and water. Applications have ranged from 2½ to 7 gallons of mixture per acre. Damage to conifers is insignificant if applications are made after the new growth has hardened off in late summer, and concentrations are not stronger than two pounds acid equivalent per acre.

Aerial application costs range from $5.00 to $14.00 per acre. Cost depends on: concentration of chemicals, size and location of the area to be treated, and method of application. Application by fixed-wing aircraft on large areas can be accomplished for about $5.00 per acre. Helicopter application on large areas costs about $8.00 per acre.

Aerial application of herbicides has many advantages of which we are all aware, but it also has some disadvantages. Drift is so serious a problem that aircraft application of 2, 4-D has been outlawed entirely, and strict limitations have been placed on ground machines in so-called "hazard areas" in California. Helicopter application in still weather, using low concentration of herbicide and large droplet size, reduces the hazard of drift. Invert emulsions of 2, 4, 5-T which make a thick, creamy spray and reduce drift are available for field trials.

Interception of spray by the overstory becomes a problem if the objective is to control understory hardwoods. Overstory softwoods are not seriously damaged by the spray, but a dense overstory prevents good coverage of the understory. Better foliage penetration is achieved by helicopter application at slow speed to attain maximum benefit from rotor prop wash.

Large areas must be treated to make aerial spraying economical, and all hardwoods regardless of value on a treated area may be killed or damaged. Smaller areas may be sprayed by helicopter, but the cost per acre of marking the areas to be sprayed increases sharply as the size of the areas decrease. Other costs also increase when numerous small areas are treated by helicopter.

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Two ground methods of herbicide application were tested in an effort to overcome these disadvantages and make foliage application of herbicides possible where aerial application is not practical or desirable. Standard tested mixtures for aerial applications were used in machines which put the material out in a fine mist similar to that applied from the air.

THE TRUCK-MOUNTED MIST BLOWER

A truck-mounted mist blower of the type commonly used to spray shade trees was tested in 1957. The blower, a self-powered unit which could be mounted on a tractor, jeep, or truck was used. It delivered 10,000 cubic feet of air a minute at 150 miles per hour at the nozzle. Trees up to 70' in height can be sprayed with this type of machine. Easier coverage of the forest could be achieved by mounting the machine on a crawler tractor instead of a truck so that travel in the forest would not be controlled by road location. Machines specially made for forest mist spraying are now available.

SPRAY MIXTURES

Four aerial type mixtures of spray were used in the truck-mounted mist blower tests on August 27, 1957.

Test 1: One pound 2, 4, 5-OS acid equivalent in a gallon of fuel oil and 3 3/4 gallons of water applied at the rate of 5 gallons of mixture per acre assuming a 5-chain (330 ft.) depth of penetration from the location of the mist blower.

Test 2: Two pounds 2, 4, 5-OS acid equivalent in a gallon of fuel oil and 3½ gallons of water applied at the rate of 5 gallons of mixture per acre, again assuming 5 chains of penetration from the location of the mist blower.

Test 3: One pound Kuron in the same quantities of oil and water as Test 1.

Test 4: Two pounds Kuron in the same quantities of oil and water as Test 2.

Spray mixtures were formulated assuming a 5-chain penetration of spray from the truck location. Less than one-half that depth of penetration was achieved. No reasonable estimate of spray concentration per acre could be made, because there is no way of knowing how much spray material blew out of the area.

METHOD OF APPLICATION

The truck-mounted mist blower was operated from a woods road. A trial run was made with a nozzle attachment that gave a very fine spray which went only a short distance. With the nozzle removed, the spray mixture flowed directly into the air stream producing larger size droplets, and greater distance was achieved. All subsequent strips along the road were sprayed without the nozzle attachment. The truck moved at five miles per hour spraying on both the forward and backward pass until all the mixture for a given strip was used up. Some softwoods were in the direct path of the spray blast, and some large hardwood intercepted the air stream and decreased the effective distance of penetration. In this test, good control of hardwoods resulted 150' back from the road where the machine traveled.

THE AREAS TREATED AND CONDITIONS DURING TREATMENT

The area selected for treatment with the truck-mounted mist blower was a stand of eastern white pine and hardwoods which had suffered sever blowdown in the 1938 hurricane. On the ground was a dense mixture of pine and hardwoods about 20' tall with occasional larger trees of varying size up to two feet in diameter which survived the hurricane. The vegetation selected for spraying was nearly all less than 20' tall, so that the machine could throw the material at a more nearly horizontal angle to obtain maximum penetration. Hardwoods on the area were predominantly birches, maples, and oaks. A small amount of hemlock was also present.

Eight plots were located in pairs, one on each side of the road, to test the four spray mixtures already described and the method of applying them. Conditions for the test were not ideal. Spraying was done at an early hour to get still weather, but the wind ranged from 5 to 10 miles per hour limiting penetration on the windward side and carrying the material too quickly away on the leeward sides. Arborists usually limit their work with this machine to still conditions at daybreak, at night, and other times when the air is quiet.

RESULTS FROM THE TRUCK-MOUNTED MIST BLOWING

There was little difference in hardwood control between one-pound and two-pound concentrations of 2, 4, 5-OS and Kuron. Kuron was less effective than 2, 4, 5-OS in killing large trees. Pine in the direct blast of the spray showed some damage after three weeks, but this was very difficult to detect a year after the spraying. Hemlock in the direct blast showed greater damage, and a few of the damaged terminal buds did not put out new growth the following year. Parts of these trees were soaked to the running off point with spray. Scattered cull hardwood trees up to two feet in diameter were killed. The line of killing spray penetration was fairly sharp, and some trees at maximum penetration distance were damaged on one side only. White oaks, which proved most susceptible in all tests were killed beyond the line of general killing penetration. The tops of larger oak trees above the general crown canopy beyond this line showed some damage.

Some sprouting occurred, perhaps because the tissues died before they could carry the chemical to the roots. Spray concentrations were strong and foliage browning was very rapid. The low brush had most sprouting with progressively less sprouting on larger trees. Only one area had sprouts on trees 2 inches or more at breast height. Sprouting does not appear to be a serious obstacle to hardwood control with mist blowers.

Table 1. Effectiveness of Truck-Mounted Mist Blower Applications of Herbicide

Test	Low Brush (0.6 ft. to 0.5" DBH)										Tall Brush (0.5" DBH to 1.9" DBH)										Trees (2.0" DBH and up)									
Area	Dead[2]		Severe[3]		Light[4]		None[5]		Sprouts[6]		Dead		Severe		Light		None		Sprouts		Dead		Severe		Light		None		Sprouts	
No.	S/A[1]	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%
2, 4, 5-OS (Area #1 at 1 lb. per acre Area #2 at 2 lb. per acre)																														
1	58	63	16	17	3	3	16	17	19	20	80	64	26	21	13	10	6	5	13	10	19	54	10	29	6	17				
2	77	64	24	20	14	12	5	4	26	22	96	90	2	2	7	6	2	2	26	24	24	83	5	17						
Kuron (Area #3 at 1 lb. per acre Area #4 at 2 lb. per acre)																														
3	75	75	8	8			17	17	33	33	58	70			17	20	8	10	25	30	25	76			8	24				
4	53	55	10	10	13	14	20	21	20	21	50	72	3	4	10	14	7	10			26	100								

1 S/A - Stems per acre

2 Dead - 80% or more defoliated

3 Severe - 50% to 80% defoliated

4 Light - 20% to 50% defoliated

5 None - Less than 20% defoliated

6 Sprouts - If present

Hardwood control within the limit of penetration of the spray, 150 feet down wind and 50 feet against the wind, was uniformly good on all plots. Damage to softwood was light, but the distance of penetration was disappointing; so it was decided to test other more portable machines the next year. The truck-mounted machine merits further trial, however, because it requires far less physical effort to operate than the other machines tested, and it will throw the spray three times higher than can the small portable machines currently available. If well protected, the machine could travel on or behind a tractor and go most anywhere in the forests.

COST

No reliable cost data could be determined because the tests were accomplished in a little over an hour and the crew was inexperienced in this kind of work.

THE SHOULDER-MOUNTED MIST BLOWERS

Two shoulder-mounted mist blowers of Dutch manufacture, weighing 31 pounds empty, were tested from August 12 to August 20 in 1958. These machines could blow mist to a height of 20 feet in still air. By holding the nozzles still and letting the air stream build up, 30 feet of height penetration could be achieved. In normal operating situations, $2\frac{1}{2}$ gallons of spray material were delivered in 30 minutes by each machine. Three men sprayed ninety-six acres in five days employing the two machines.

SPRAY MIXTURES

Two spray mixtures were used in the shoulder-mounted machine tests from August 12 to August 20, 1958. One pound 2, 4, 5-OS acid equivalent in $2\frac{1}{4}$ gallons of fuel oil was applied at the rate of $2\frac{1}{2}$ gallons per acre for most of the tests. One test using Kuron in place of 2, 4, 5-OS was made. Fuel oil only was used as a carrier for the herbicide to simplify mixing. One pound acid equivalent per acre was found adequate to control hardwoods in the 1957 truck-mounted mist blower tests and in previous aerial tests by others. This low rate was also used so that conifers which might be caught directly in the blast of spray would not be severely injured.

METHOD OF APPLICATION

In the 1958 tests, two shoulder mounted mist blowers with detachable spray tanks were used by two men operating as a team. A third man serviced the machines, replaced empty spray tanks with full ones, refueled the motors when necessary, started them if they stalled, and packed five-gallon cans of spray mixture from the truck to strategic locations in the forest for filling the spray tanks. This team organization made for efficiency and kept the machines operating most of the time. It was hot, unpleasant work since the loaded machines weighed 50 pounds and the air was full of fine drifting oily mist. Some spray material came in contact with the skin, but no irritations occurred.

Strips were run at 20-foot intervals; ten strips involving approximately 2,000 feet of travel covered an acre. This travel was carefully gauged to be accomplished in 30 minutes, because the mist blowers in normal operating situations put out $2\frac{1}{2}$ gallons of material in that time. Stand area was measured on aerial photos before spraying to help insure uniformity of coverage at $2\frac{1}{2}$ gallons per acre. The two mist blowers were operated in tandem 20 feet apart. The man on the outside edge put out short strips of toilet paper at frequent intervals to orient the inside man on the next strip. When desirable, toilet paper was hung high on branches by putting it in the air stream of the blower. About twenty acres per day were treated over a five-day period. Twelve five-gallon cans of spray formulation were taken into the field each day, and two pack boards were used to carry the material back into the forest where necessary. Special care was taken to agitate the spray mixture before use.

AREAS TREATED AND CONDITIONS DURING TREATMENT

The seven areas treated by shoulder-mounted mist blowers from August 13 to August 20, 1958, represent a variety of conditions where small portable mist blowers could be effective. A major limitation of this machine is the relatively low height to which the material can be carried in the air stream. Twenty feet of height is easy to achieve, thirty feet can be secured in still air by holding the nozzle in one place to let the air stream build up. The great advantage of shoulder-mounted machines is their portability.

Area 1 was a stand of sapling hardwoods 20 to 30 feet tall over natural white pine 4 to 10 feet in height. Hardwood species were principally birches, maples, and oaks with a few aspen and ash. A hard driving rain interrupted the work at 4:00 p.m., and probably washed some of the spray material from the trees. The work in this stand continued next day on a damp, foggy morning when the leaves were drenched with water. The leaves dried off during the day, but another hard rain fell at 7:00 p.m. The wind was still during this test.

Area 2 was an eight-year old Norway spruce plantation invaded by hardwoods, white pine, and woody shrubs. The hardwoods were predominantly red maple and pin cherry with heights ranging up to 20 feet. Some parts of the plantation were heavily invaded by hardwoods, other parts had none. The machines were shut off where there were no hardwoods to kill. Stone walls through the area had hardwoods up to 50' tall which were also sprayed. The plantation rows served to locate travel lines for the machines. This work was done on a hot muggy day. Wind movement was less than five miles per hour. The leaves were wet at the start and became dry during the operation. A hard rain fell that evening at 7:00 p.m.

Area 3 was a natural stand of white pine invaded by aspen, gray birch, pin cherry, and a few white birch and red maple. The pine was 15 to 20 feet tall; the hardwoods were 20 to 40 feet tall with diameters ranging from 2" to 12". In most areas the hardwood existed as single scattered trees not severely competing with the pine. In other areas the hardwoods were more dense, of larger size, completely overtopping the pine. The trees were wet, and the weather was foggy while the work progressed. Later in the day the trees dried out, and they were fairly dry by 2:00 p.m., when a shower occurred. Wind movement was less than five miles per hour.

Area 4 was a natural stand of pine ranging from seedling size up to 18' in height. Pine stocking ranged from very sparse to very dense. The hardwoods present were of the same general height or overtopping the pine. Species were predominantly gray birch and red maple with occasional other birches and oaks. There was an abundance of other woody plants like huckleberry and sweet fern in the more open situations. The wind ranged from 10 to 20 miles per hour and seemed to carry the mist away from the lower vegetation such as huckleberry, which occurred in pure stands about 3 feet tall. The huckleberry was not affected by the spray. None was found to be damaged on 15 plots.

Area 5 was a pine stand cut in the winter of 1957 by the shelterwood method. Sparse pine and hardwood regeneration was present. Most of it, small in size and not very evident at the time of cutting, was beginning to grow well at the time of spraying. The wind was still during the spraying. Rain fell that evening.

Area 6 was a twenty-year old pine and hardwood stand of the same general height, with some larger overtopping hardwoods. Tree species represented were red maple, gray birch, pin cherry, red oak, and white oak. The day was cool; wind was 10 to 20 miles per hour. No rain fell for several days after the spraying.

Area 7 was a forty-year old pine and hardwood stand with the hardwoods in the upper crown canopy. The stand was composed of red oak, white oak, and red maple. Black birch, gray birch, white birch, and yellow birch were also present along with beech and pin cherry. The weather was the same as for area 6. This area was treated with Kuron at one pound acid equivalent per acre. All the others were treated with 2, 4, 5-OS at the one-pound rate.

RESULTS FROM THE SHOULDER-MOUNTED MIST BLOWING

Results were determined by measuring seventy-four concentric circular plots mechanically located by compass and pacing, early in September the year after spraying.

The oaks proved to be most susceptible to the herbicide. Some oaks up to 60 feet in height were killed by the shoulder-mounted rigs, where the maximum height of other species killed was about 30 feet. Aspen was the most resistant tree species to the spray. Woody shrubs like huckleberry, blueberry, sweet fern, and laurel were less damaged than hardwood tree species of the same size. More effort to get the material directly on the lesser vegetation would probably improve control of this material. In the work machine operators were instructed to direct the spray at hardwoods interfering with the growth of softwoods, and as a consequence the spray was seldom directed at the low brush.

Table 2. Effectiveness of Back-Pack Mist Blower Applications of Herbicide

2, 4, 5-OS at 1 lb. per acre

Test Area No.	Low Brush (0.6 ft. to 0.5" DBH)										Tall Brush (0.6" to 1.9" DBH)										Trees (2.0" DBH and up)									
	Dead[2]		Severe[3]		Light[4]		None[5]		Sprouts[6]		Dead		Severe		Light		None		Sprouts		Dead		Severe		Light		None		Sprouts	
	S/A[1]	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%
1	167	33	167	33	167	33			167	33	266	20	133	10	666	50	266	20	67	5	248	50	82	16	79	16	89	18		
2	2300	39	1800	31	600	10	1200	20	700	12	420	30	200	14	60	4	740	52	20	1	58	33	46	26	38	21	36	20		
3	1000	89			125	11			125	11	200	47	50	12	75	18	100	23	50	12	30	36	15	18	18	22	20	24		
4	67	6	334	29	467	41	267	24			332	49	53	8	93	14	200	29	13	2	116	39	58	19	81	27	46	15		
5	312	58					224	42	78	15	62	68	15	16			15	16	15	16	26	53	9	19	6	12	8	16		
6	2340	35	780	12	1092	16	2496	37	468	7	832	72	169	15	92	8	62	5	246	21	225	60	69	19	53	14	27	7	21	6
Ave.	1031	39	513	20	408	15	696	26	256	10	352	36	103	10	303	31	230	23	68	7	117	47	46	19	46	19	38	15	4	2
	Kuron at 1 lb. per acre																													
7	333	43	111	14	222	29	111	14	111	14	466	78	89	14	22	4	22	4	44	7	128	28	88	19	156	34	86	19		

1 S/A - Stems per acre

2 Dead - 80% or more defoliated

3 Severe - 50% to 80% defoliated

4 Light - 20% to 50% defoliated

5 None - Less than 20% defoliated

6 Sprouts - If present

Table 3. Effectiveness on Species of Back-Pack Mist Blower Applications of Herbicides

2, 4, 5-OS at 1 lb. per acre

Species	Low Brush (0.6 ft. to 0.5" DBH)										Tall Brush (0.6" to 1.9" DBH)										Trees (2.0" DBH and up)									
	Dead[2]		Severe[3]		Light[4]		None[5]		Sprouts[6]		Dead		Severe		Light		None		Sprouts		Dead		Severe		Light		None		Sprouts	
	S/A[1]	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%
Alder	31	67			15	33					9	29	3	10	3	10	16	51	3	10										
Aspen	46	100									12	40			6	20	12	40			1	12	2	25	2	25	3	38		
Birch black											6	67			3	33					6	55	1	9	3	27	1	19		
Birch gray	31	100							31	100	56	40	25	18	53	38	6	4			24	42	10	17	14	24	10	17		
Birch white															6	67	3	33	3	33	6	37	3	19	4	25	3	19		
Cherry	31	33			31	33	31	33			62	78	6	7	3	4	9	11	3	4	10	37	10	37	5	18	2	8		
Maple red	62	40	31	20	31	20	31	20	15	10	140	66	37	18	9	4	25	12	40	19	39	54	14	19	12	17	7	10	4	6
Oak red	15	100									28	61	3	6	3	6	12	27	3	6	17	80	2	10	2	10				
Oak white	92	100									37	100							3	8	9	82	1	9			1	9		
Shrubs	416	32	216	16	262	20	416	32	62	5	40	50	6	7	19	23	16	20	3	4										

1 S/A - Stems per acre

2 Dead - 80% or more defoliated

3 Severe - 50% to 80% defoliated

4 Light - 20% to 50% defoliated

5 None - Less than 20% defoliated

6 Sprouts - If present

Pine, hemlock, and spruce caught directly in the blast of the spray and wetted to the point of run-off were temporarily damaged. Needles quickly browned, and the stems of some leaders and side branches browned also. These trees were marked for observation during the next growing season. Little damage was observed at that time. Five softwoods were recorded as damaged on the 72 plots measured. One of these had the terminal killed. Most damage occurred in tight spots where the operator had to "bull" his way through tangled underbrush and vines and was more concerned with his footing than with direction of the spray. Hemlock and spruce are more susceptible to damage than pine. Damage to softwoods as a whole was very light; none were more than 20% defoliated.

All the sites treated had sufficient hardwood control to release the softwoods except Area 7, and even here 48% of the broadleaf trees were severely damaged or killed. The lesser degree of control on Area 7 is attributable to the size of the material treated. The crown canopy of the forty-year old stand of pine and hardwoods was 40 to 50 feet above the ground and for the most part beyond the effective range of the equipment. Good hardwood control was achieved in other stands up to 30 feet in height. In Area 7 under optimum conditions trees in excess of this height were killed, but in general 30 feet seems to be the ceiling for satisfactory operation of back-pack mist blowers currently available. Taller stands should be treated from the air or with larger blowers. It is noteworthy that in Area 7 a very high proportion (93%) of the tall brush was killed or severely damaged, because here the mist was confined within the stand under the crown canopy of the trees overhead. Some of the shorter pines may have prevented penetration of spray to the taller hardwoods in the overstory. Many of these hardwoods had the lower branches killed or severely injured by the herbicide.

Reasonably good selectivity can be exercised with shoulder-mounted mist blowers. By shutting off the flow of spray, areas of desirable hardwoods as small as one-tenth acre in size can be reserved in the midst of a large treated area. The larger truck or tractor mounted blowers are less selective; helicopters are still less selective; and fixed-winged aircraft are the least selective of all.

COST

Ninety-six acres were sprayed with the back-pack mist blowers at a cost of $6.40 per acre using two machines and a three-man crew. The cost per acre would increase if a single machine were used.

Table 4. Per Acre Cost of Back-Pack Mist Blower Applications of 2, 4, 5-OS

Item	Cost
1 pound 2, 4, 5-OS acid equivalent @ $45.00 per 5 gal.	$ 2.25
$2\frac{1}{4}$ gallons of fuel oil @ 20¢ per gal.	.45
Labor costs: 3 men @ $60.00 per day	3.23
Machine cost: operation (5¢), depreciation (38¢), maintenance (4¢)	.47
	$ 6.40

Ground application of herbicides by mist blowers to control hardwoods should extend the use of chemical foliage sprays to areas where aerial spraying is not possible or desirable.

HERBICIDE TECHNIQUES FOR TIMBER STAND IMPROVEMENT

John H. Kirch[1]

The primary purpose of a herbicide program in forestry is to weed the forest of undesirable trees competing for the light, moisture and nutrient requirements of the more desirable species.

We have only begun to realize the potential value of herbicides as tools in forest management. About 489,000,000 acres, or one-fourth of the total land area of the United States, is classed as commercial forest land(1). On nearly all of this land, at some time in the tree crop rotation, silvicultural weeding with herbicides can be employed to advantage.

There are four broad forest areas in this country where herbicide techniques have been perfected and are being widely used to control undesirable trees in favor of those better suited to the site. These areas are the Southeast, the Pacific Northwest, the Lake States and the Northeast.

The most pressing need for herbicides exists in the Southeastern part of this country where brush hardwoods are encroaching on 103,000,000 acres of pine land at the rate of over 600,000 acres per year, or nearly 1800 acres per day(9). Several hundred thousand acres of timber and pulpwood land are chemically weeded every year in the eleven state area extending from Eastern Texas and Oklahoma to the Atlantic Coast. Two commercial companies in this area, between them, chemically treat over 50,000 acres per year as part of their pine regeneration programs.

In the Pacific Northwest which includes the states of Washington, Oregon, Western Montana and Western Idaho, unless planting or direct seeding by air establishes Douglas fir (Pseudatsuga taxifolia) and related species within one to three years after clearcutting, the area is taken over by a whole complex of brush species, many of which are impossible to control with known chemical or mechanical methods(8). Ceanothus (Ceanothus spp.), Manzanita (Manzanita spp.), vine maple (Acer circinatum), big leaf maple (Acer macrophylla), alder (Alnus rubra) and willow (Salix spp.) are potential invaders of 35,000,000 acres of high site land in this area.

In the Lake States of Minnesota, Wisconsin and Michigan where red pine (Pinus resinosa), white pine (Pinus strobus) and jack pine (Pinus banksiana) are species of commercial importance; hazel (Hamamilis virginia), alder (Alnus spp.), aspen (Populus tremuloides), oak (Quercus spp.) and willow (Salix spp.) are constant competition throughout the life of many conifer plantations.

The Northeastern section of the country, which for the purpose of this discussion we will say includes the states of Pennsylvania, New Jersey, Ohio, Delaware, Maryland, Kentucky, West Virginia and New York as well as the New England States, presents a unique problem in the use of herbicides. Some of the most valuable hardwood forests in the country grow in the river bottoms of this section. Vast areas of white, red, shortleaf (Pinus echinata) and loblolly pine (Pinus taeda) as well as spruce (Picea spp.) and balsam fir (Abies balsamea) are also found here. The selection of the proper herbicide technique for use in a forest management program is more difficult in this area than it is in any of the three areas previously mentioned.

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The presence of both hardwood and conifer forests in the area, and the intermixing of the two on many sites make blanket prescriptions for weed tree control almost impossible. Each area must be carefully studied and a prescription written that will favor the most valuable species for the site.

In all four sections of the country, our objective as foresters is to grow the tree species best suited to the site. We should never allow ourselves to be misled into thinking that our objective in using herbicides is to kill trees rather than to grow them. We cannot kill all undesirable weed trees in a forest any more than a farmer can kill every weed in his corn, wheat or soybean field. Yet, this does not stop the farmer from using 30,000,000 pounds of 2,4-D every year to double and triple his yields.

Regardless of whether we are using chemicals or some mechanical method of release or site preparation, weed trees will return and will always be with us. But, like the farmer, we can increase yields by obtaining a degree of control with these mechanical and chemical methods. As many forest managers have expressed it, we can buy a few critical years freedom from weed tree competition to release our tree crop.

With the specific goal of growing trees clearly in mind, let us consider the tools that are available and the techniques that show promise for controlling weed trees, particularly in the Northeastern area.

There is some confusion today on the subjects of weeding for site preparation and weeding for release in regeneration work. Generally speaking, our best chemical tool 2,4,5-Trichlorophenoxyacetic acid, is not the best answer for site preparation on areas supporting dense stands of hard to kill species such as red maple (Acer rubrum), ash (Fraxinus spp.), water oak (Quercus nigra), laurel (Kalmia latifolia) and rhododendron (Rhododendron maximum). Even if we could kill these species with 2,4,5-T at a per acre rate that the value of the tree crop grown on the land could justify, the dead stems would still be so thick that planting would be difficult and costly. If direct seeding is to be used, herbicides do nothing toward preparing a seedbed. In order for herbicides to be used successfully as a site preparation measure, the underbrush should be made up predominantly of susceptible species such as alder, hazel, gum (Nyssa sylvatica), oak, hickory (Carya spp.), cherry (Prunus serotina) and birch (Betula spp.) and should be sparse enough for easy planting.

A cheaper approach in the long run to regenerating these dense thickets of difficult to kill species may be to mechanically clear them with bulldozers equipped with "KG" blades. Clearing by this method costs from sixteen to twenty-five dollars per acre, but if the land, due to location or high site index, is valuable and must be returned to production the cost may be justified. Clearing in strips, or clearing without windrowing and burning are means of reducing the cost of mechanical clearing. You do not need to create a park-like condition for trees to grow.

The possibility of using controlled burns to remove small dense understory brush and prepare a seedbed should always be considered in site preparation work. Where sufficient logging slash or needle duff from overstory pine is present in the ground litter to carry a hot fire, controlled burning followed by planting may be the cheapest solution to reforesting the land.

Occasionally, where there is not enough litter, but where susceptible species are prevalent, it is possible to use herbicides to set up an area for controlled burning. The chemical is applied at the beginning of the growing season as soon as foliage has reached full size, and the burning is done at the end of the growing season or the following year when foliage and stems are dead and dry. Planting or seeding should be done immediately after the burn to take advantage of the release obtained.

More work needs to be done on this chemical-fire combination treatment to determine the ideal time to use the controlled burn. Following chemical treatment too closely with fire will not allow sufficient time for translocation of chemical to plant roots. The result will be vigorous resprouting from the root collar which can cause severe competition to newly planted trees or seedlings.

It is interesting to note that the main reason for the brush hardwood problem on millions of acres of valuable pine land in this country today is largely due to the intensive fire control now in practice. If controlled burning can be substituted for the wild fires of the past, brush can be temporarily controlled and planting sites can be prepared fairly economically.

Once a desirable species has been established on a site, fire and mechanical clearing can no longer be used. Selective techniques that favor one species over another are required. These are release situations and are ideally suited to herbicide programs. As a general rule, the greatest return from money spent on a single herbicide treatment will be realized on areas where desirable species are already established and release is needed.

For the remainder of this discussion let us consider the specific herbicide techniques that may be used in these release programs.

A. FOLIAGE SPRAYING BY AIR

The use of aircraft to apply herbicides for conifer release in this country is a firmly established practice. The technique is most economical on areas in excess of 500 acres. Most of the work is done by helicopter aircraft, using 1½-2 pounds per acre of a low volatile ester of 2,4,5-T in 2 quarts of oil and 4 gallons of water[5][7]. Examples of low volatile esters in use today are the butoxy ethanol and propylene glycol butyl ether esters. Timing of aerial sprays should coincide with full foliage development on the weed tree species and should be applied after the new growth on conifers has hardened off. Soil moisture should be sufficient for good growth and relative humidity should be high. For uniform coverage, swaths should overlap on 30 to 40 foot centers and should be flagged. Boundaries of sprayed areas should be clearly marked. Three points need emphasis in applying low volumes of spray solution by air.

First is timing. When we apply a rate of 2 pounds per acre of 2,4,5-T in only 5 gallons volume to the foliage of trees, we are relying completely on the plants ability to translocate this material to the roots in sufficient quantity to kill the plant and prevent sprouting. Since it is generally understood that 2,4,5-T moves with the plant foods, the timing of foliage sprays must coincide with downward food movement in the plant(4)(6)(12)(14). Hence the recommendation to spray after leaves have fully developed on the weed tree species and when active growth is in process.

The second important point in aerial application concerns the use of oil in the spray carrier. Oil is added in small amounts for the purpose of aiding penetration of the cuticle layer in plant foliage. Crafts(4) states that "... oil, soaking into the cuticle, tends to saturate it with respect to its lipophyllic capacity, and so to free the 2,4-D ester for movement into the phloem in the aqueous phase". The problem involved with oil is the selection of the proper amount of oil to cause this saturation of the cuticle without severe damage to the living cells in the plant foliage. 2,4,5-T must be translocated by these cells and the longer they can be kept alive the more 2,4,5-T will be moved toward the roots. The selection of 2 quarts of oil per acre as the amount to use in aerial spraying is a compromise between the amount needed to enhance hardwood foliage penetration and the amount the conifers can stand without severe injury. This brings us to the third important point in aerial spraying for conifer release, that of conifer selectivity.

The widespread use of 2,4,5-T in aerial application for conifer release has led a number of people to believe that 2,4,5-T is inherently selective on conifers. This is not the case. We have obtained an acceptable degree of selectivity by applying not more than 2 pounds per acre of this compound in not more than 2 quarts of oil and 4 gallons of water at a certain time of the year. It is well to remember that this same compound at higher rates and volumes in an oil-water emulsion is used to kill conifers on utility rights-of-way.at the same time of year as it is being used to release these conifers in forests.

The recommendation for conifer release given here is by no means a hard and fast rule. In the Northeastern area, McConkey(13) has found that 1-3 pounds of 2,4,5-T in 1 3/4 gallons of diesel oil per acre has not seriously damaged white and red pine (Pinus resinosa) in Maine and has given adequate release. Changes should not be made in either the rate or volume recommended by McConkey without first checking the conifer tolerance to the proposed changes. The point here is that chemical rate, carrier, volume and timing must be carefully evaluated to avoid injury to conifers and to obtain acceptable control of weed trees.

B. FOLIAGE SPRAYING BY MIST BLOWERS

The need for equipment that will apply the low volumes of spray used in aerial application to understory hardwood brush has led to the development of tractor mounted and portable mist blowers. One of the greatest problems in aerial application is getting good penetration to the understory weed trees when a dense overstory is present to intercept the spray. Repeat sprays by air that remove the overstory and then the understory in a two canopy weed tree situation have been successful.

However, the capacity of the mist blowers to apply the same 5 gallon per acre volume as the aircraft to understory canopies up to 30' in height has virtually eliminated the need for aerial application on smaller areas of accessible terrain(3)(15). Mounted on D-4 or John Deere 440 tractors these blowers can negotiate dense brush and suprisingly rough terrain. Portable backpack blowers are ideal for spot treatment or for treating areas just a few acres in size.

Two pounds of low volatile ester of 2,4,5-T in 2 quarts of oil and 4 gallons of water are used through the blowers. Costs are generally equal to those encountered in aerial application. In respect to timing, chemical, carrier and volume, the recommendations for mist blowing are identical to those for aerial application.

Before leaving the subject of foliage application, mention should be made of the problem of drift and what is being done about it. Drift to susceptible crops in the Northeastern area is an ever present hazard in forest spraying by helicopter or mist blower.

In recent years considerable research has been done on the thicker, more viscous invert emulsions to control this drift(2)(10)(11). Applied by helicopter through the special centrifugal disc developed for invert emulsion spraying, a considerable reduction in drift over that experienced with conventional aerial spray emulsions has been obtained. In aerial application, where there is danger from drift the invert emulsions of 2,4,5-T at 2 pounds per acre in 5-6 gallons volume per acre can be used, but with the clear realization that no formulation is a substitute for good common sense in aerial application. Do not use the invert emulsions in winds over 5 mph, and employ aerial applicators who have had experience flying these emulsions. Stay downwind from crops and leave buffer strips between sprayed areas and crop land.

Equipment has not yet been developed for applying the invert emulsion through mist blowers. Inverts are not recommended for use in this equipment at this time.

The use of aircraft or mist blowers to apply foliage sprays is confined largely to conifer release work. Selective weed tree control in the hardwood forests of the northeast cannot be done with overall foliage applications, because our most valuable hardwoods are killed or severely damaged by even the lowest rates of 2,4,5-T. At present, there are no herbicides commercially available that when applied as foliage sprays favor one hardwood species over another. However, in our cut surface treatments which include frilling, girdling and tree injecting we have individual tree treatments which are economical to use in weeding hardwood as well as conifer stands.

C. FRILLING AND GIRDLING

For years, frilling and girdling trees by use of the axe and girdling machines has been a standard practice in the northeast. 2,4,5-T at 20-40 pounds per 100 gallons of diesel oil solution has been applied to these cut surfaces. Sodium arsenite has also been used extensively, but due to its toxicity it has gradually been replaced by 2,4,5-T. Kills of 90% or better can be expected on most weed tree species found in the northeast by frilling or girdling and treating with 2,4,5-T.

However, where more than a few hundred stems per acre must be treated a more rapid and cheaper method that is gaining in popularity in other sections of the country is to use the tree injector.

D. TREE INJECTING

Most tree injectors are hollow cylinder tools about four feet long, with a cutting bit in one end. Either hand operated or automatic triggering mechanisms for releasing the chemical into the cut made by the bit are used. The injector is thrown at the base of a tree at an angle of approximately 60° with the ground. Injections are spaced around the base of the tree at 1.5 to 2 inch intervals. Trees from 1 inch to ten inches in diameter are best suited to this treatment.

A solution of 20 pounds of 2,4,5-T low volatile ester, or more recently, the combination of 2,4-D/2,4,5-T at this rate have given 95% kills of oak, hickory, cherry, maple and related species(8)(16). Care must be used in making certain that the injections penetrate through the cambium layer of the tree and into the inner wood. Failure to train tree injector crews in this one technique can result in very poor results.

Over 10,000 of these tree injectors have been sold to foresters in this country. One commercial company in the south has treated over 20,000 acres with tree injectors at a cost of approximately $10.00 per acre. This was on land where up to 2000 stems per acre were treated(3).

In addition to being ideally suited to the weeding of hardwood stands where individual stem treatment must be used tree injecting is also the most effective treatment we have for species that are hard to kill by foliage sprays, such as maple, ash and beech (Fagus grandifolia). This technique may be used at any time of the year.

E. BASAL SPRAYS

Basal spraying of small weed tree stems less than 1 inch in diameter is a technique employed by some forest companies. The technique is slightly different than that commonly used on utility rights-of-way. Rather than wetting the bottom 12-18 inches of the stem, only the root collar zone is wet to run-off in forest operations. Backpack sprayers equipped with three foot extension wands are used. Pressures are kept very low, so that material barely flows through the nozzle. Twelve to sixteen pounds of 2,4,5-T or 2,4-D and 2,4,5-T per 100 gallons of diesel oil may be used. This treatment is effective at any time of the year, but requires careful supervision to insure that enough material is applied to obtain a good kill.

F. COMBINATION TREATMENTS

No one of these herbicide application techniques will solve all the weed tree problems in northeastern forests. Most forest companies have found that their most effective control programs involve combinations of these techniques.

For example, a very effective program in the southeast today consists of summer treatments with the tractor mounted mist blower to kill back understory brush up to 30 feet in height.

This is followed by planting in the Fall and Winter. The final step is to remove the overstory canopy, which usually consists of 300-500 stems per acre, with tree injectors after the seedlings have become well established(3). This program eliminates any herbicide injury to newly planted seedlings and takes advantage of the light shade from a high overstory canopy during the first critical years of a seedlings establishment.

There is much yet to be learned and many improvements to be made in the herbicide techniques for timber stand improvement given in this paper. We have a number of tools that can help us, but we should try now to refine them. We need more information on timing of our foliage sprays to coincide with food movement in plants. Good basic experiments by research foresters using radioactive 2,4,5-T and other advanced techniques available today could contribute greatly toward solving this problem, and also the problem of sprouting following foliage spraying. The control of basal sprouting is one of the greatest single problems we have in the weed tree control field. We must find a way to activate the dormant buds that give rise to these sprouts while there is still sufficient herbicide in the plant to move into these sprouts and kill them.

Different rates and formulations should be tried in our tree injector work. Seasonal applications with injectors and basal spray treatments should be further evaluated. All of this research information should continue to be reported in the Northeast Weed Control Conference Forestry Section for the benefit of foresters throughout the region.

It is hoped that the information presented here has contributed a little to your understanding of herbicides and how they can be used in improving forest stands. More important, it is hoped that your curiosity has been aroused and that some of you will want to work on the unsolved problems in this field.

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AQUATIC WEED CONTROL AND RELATED PROBLEMS AT LAKE MOHAWK, NEW JERSEY A PRIVATE LAKE COMMUNITY

Paul C. Castellanos, Lake Supervisor

This paper is written mainly for the purpose of focusing attention on the aquatic weed problem of the private and small lake operator. Private lake operators suffer certain disadvantages that State controlled bodies of water do not have. They also enjoy certain advantages. State controlled bodies of water in New Jersey can and do pool their experience and technical knowledge. The private lake operator depends mainly upon the guidance of chemical concerns or upon the knowledge of temporary success at a nearby body of water.

We have found that no two bodies of water are the same as regards to fertility, chemical constituents, the amount of seeds stored in the mud, or the kind of vegetation. Over-generalization can therefore be misleading.

The private lake operator, on the other hand, has the advantage of being able to organize more effectively for a common purpose. If the overall problem is clearly stated to the community, the question of continuity of funds does not present itself every year. It is not only the problem of the waterfront property owner, but the community as a whole as it affects all nearby realty values.

In presenting this paper we do not lay claim to new scientific deductions. We should confide to you now, there is one mark of distinction that this speaker possesses that sets him apart from other speakers at this erudite convention - he possesses no scientific degrees. He feels that he must gingerly tread through a mine field of technical knowledge that may explode at any moment and he could be trapped by his own logic. Nevertheless, as Lake Supervisor of Lake Mohawk, we have had some years of experience on the firing line, and this paper may serve as a yardstick of evaluation when compared with other privately controlled bodies of water confronted with the same problem. More correctly stated, it is a progress report.

To properly present a fifteen year effort we submit a chronological background of our activities. The Lake Mohawk Reservation is a community of 2500 acres, which lie within the Township of Sparta, Sussex County, New Jersey. The Lake Mohawk Country Club owns and maintains three bodies of water, used solely for recreational purposes. The main body of water is Lake Mohawk, consisting of 960 acres, three miles long and one-half mile wide. Upper Lake Mohawk is 24 acres and Alpine Pool, a three acre area, used solely for swimming. All are man-made and two are 33 years old as of 1960; Alpine Pool is 25 years old. These waters are slightly alkaline, having a pH of about 8.1.

About 1942 Lake Mohawk and Upper Lake Mohawk became infected with Potamogeton crispus. By 1950 over 225 acres were solidly covered with the growth, including all coves and about ninety percent of the shore line. The average depth of the infected area was four feet. The plant, however, was growing in water twelve feet deep. We measured some plants of this height by laying them on a dock.

During the period from 1945-1950 we tried many devices, some chemical, some physical. Our efforts were unsuccessful and the infection spread. The first report published in 1946 by the Committee on Water Pollution entitled "Aquatic Nuisance Control in Wisconsin" outlined their progress with sodium arsenite. We tried a test area 50 x 100 feet in June, 1949 where the growth was heavy. In about ten days the weeds in the treated area disappeared. Our Weed Committee at that time decided to proceed with caution before embarking on a program involving the use of sodium arsenite and no further application was made in 1949. On April 22, 1950, application was made by a power driven tree spraying equipment at 3.7 PPM in a heavily infected cove. No plants had yet appeared. The purpose of this test was to determine the resultant concentration of arsenic at various distances and elapsed time from point of application. Fifteen samples were taken in one gallon pyrex bottles and the results were as follows:

Date of Sample	Sample No.	Location 1 Center of Area Treated	Location 2 50 Ft. Outside	Location 3 Spillway 1/2 Mile
April 22, 1950 Weather Clear	1	1.12 ppm	0.50	0.02
April 23, 1950 Weather Clear	2	0.05*	0.34	0.02
April 24, 1950 Weather Clear	3	2.90	0.21	0.01
April 25, 1950 Rain	-	-	-	-
April 26, 1950	4	0.18	0.09	0.03
April 27,28,29, 1950 Weather Clear	-	-	-	-
April 30-May 1, 1950 Heavy Rain	-	-	-	-
May 2, 1950	5	0.05	0.04	0.03

*This sample was re-checked. It is obviously too low.

Sample 1-Location 1 was taken $2\frac{1}{2}$ feet below surface. The sample was taken directly after treatment at 3.7 PPM. Arsenic had not yet diffused down toward bottom. All later samples were taken at the surface.

Sample 2-Location 1 may have been taken over a fresh water spring.

The results showing the spillway water to be 0.03 PPM were reassuring as it was lower than that permissible in drinking water. In view of these findings we increased the amount of sodium arsenite to 5 PPM and treated the most heavily infected coves in 1950. As most of the Potamogeton crispus seeds have matured into plants by June in our lake water temperature, we ceased further treatment with sodium arsenite at that time. As arsenic is ubiquitously distributed in soils in varying amounts, we took six water samples in June, 1950 after treatment had ceased; five from various inlets and one at the spillway. The results were as follows:

Balsam Inlet, dated 6/3/50, contained - 0.03 PPM of arsenic.
The Beach Inlet, under same date, contained - 0.01 PPM.
The Beiser Pond Inlet - 0.02 PPM.
The Marine Pond Inlet - 0.03 PPM.
The Pumping Station No. 5 Inlet - 0.01 PPM.
The Outlet, dated 6/11/50 - 0.03 PPM.

Two inlet samples were as high in arsenic as the outlet. It indicates that the arsenic applied had little effect on the outlet water, if any. Moreover, these findings established the reason for the presence of arsenic in previous samples taken at Spillway (Location 3, Samples 1 - 2 and possibly 3) on April 22nd to 24th.

Since 1950 we have used sodium arsenite annually each May. The quantity used showed a general increase from 1950-1956. Because of a general improvement in the growth density, the amount used in the last four years (1957-1960) showed a decrease. We made further examination of our water and lake bottom in October, 1960, to determine whether or not we were building up arsenical residual after 10 years application of 161,000 pounds of arsenic trioxide over the period (as Atlas "A"). For the purpose of comparison we took bottom samples of nearby Senaca Lake where no sodium arsenite had ever been applied. The two bottom samples taken at Lake Mohawk, and one taken at Upper Mohawk, were taken where the arsenic residual, if any, was likely to be the greatest. The sodium arsenite is loaded from drums to barge at these points. The after-drip of the transfer hose is run into the water after loading, thereby substantially increasing the amount at that point. The greatest amount of loading occurs at the point where Sample 4 was taken. The results of the finding in Sample 4 compared with Sample 1, where no sodium arsenite was ever applied, shows no appreciable difference.

The samples were filtered to remove supernatant water, and each solid was washed with one liter of distilled water. The residue was then oven dried and weighed. All samples were submitted for arsenic analyses with the following results.

1. Pond Bottom, Senaca Lake, taken 10/14/60

Dried Solids	577 grams	0.0006% arsenic
Supernatant Water	56 milliliters	0.65 mg As/liter
Wash Water	900 milliliters	0.35 mg As/liter

2. Lake Bottom, Upper Lake Mohawk, at Boat Dock adjacent to swimming area, taken 10/20/60

Dried Solids	124 grams	0.036% arsenic
Supernatant Water	320 milliliters	1.20 mg As/liter
Wash Water	970 milliliters	0.13 mg As/liter

3. Lake Bottom, Lake Mohawk, adjacent to Rainbow Trail, taken 10/24/60

Dried Solids	344 grams	0.024% arsenic
Supernatant Water	126 milliliters	1.95 mg As/liter
Wash Water	965 milliliters	0.33 mg As/liter

4. Lake Bottom, Lake Mohawk, adjacent to Beach 3, taken 10/20/60

Dried Solids	296 grams	0.0074% arsenic
Supernatant Water	185 milliliters	0.55 mg As/liter
Wash Water	950 milliliters	0.25 mg As/liter

NOTE - Two other samples have been taken, and at this writing are in the process of being analyzed. They will be included in this report if time permits.

Our method of application is by means of two wooden, flat bottom barges, 16 feet long, $4\frac{1}{2}$ feet wide and 20 inches deep, powered by out-board motors. The flow is directed through a 20 foot boom with 13 outlets evenly spaced. The boom is mounted on the bow and the solution is pumped through the boom by an engine at three gallons per minute. The form in which we used the arsenic is 40% sodium arsenite solution (four pounds arsenic trioxide per gallon). It is run from drums into a one hundred gallon tank carried in the barge. We have done away with jet nozzles and pressure. The boom is carried close to the water. The chemical seems to be equally as effective when dripped in as under pressure nozzles. There is no clogging at the nozzle tips nor drift. On windy days a plywood board is mounted on the bow to protect the operator. Rubber gloves are provided to those handling the loading from drum to barge. Treatment is done on Saturdays and Sundays only and continues for one month. Each barge works in a different area. This intermittent treatment keeps our concentration down.

To control the PPM, we time the run for one hundred gallons, a tank-full. At a uniform speed of five miles per hour and a pumping rate of three gallons per minute, it takes 35 minutes to empty the tank and the results will be 5 PPM at any average depth of four feet or fourteen gallons per acre. Experienced operators can verify their speed by checking with established landmarks. These are the theoretical objectives. In actual operation, factors such as drift, varying depths, etc. constantly creep in, causing variations from the theoretical. We balance out the variances by retreating about one-third of the area at 5 PPM. Our initial treatment begins about May 1st, before any plant has appeared on the surface. We try to destroy the plant before the seeds are formed. Many seeds stored in the mud bottom have not yet sprouted at the first treatment. The encased seed or the root structure of Potamogeton crispus seems to be invulnerable to sodium arsenite. About May 20th we find new plants have developed, presumably from seeds unsprouted at the time of the initial treatment. The area where new growth appears is again treated in the hope that the seed population will eventually be reduced. We have employed this double treatment procedure since 1958 and there has been a substantial decrease in plants per square foot since this procedure was established. This is further substantiated by a 33% decrease in our purchase of sodium arsenite in 1959-1960.

There is a constant reinfection that occurs annually. The seedlings throughout the summer and early fall are carried by the prevailing wind - at Lake Mohawk from southwest to northeast. Any protruding land acts as a seed trap. Areas that lie in the wind shadow of the prevailing wind currents hold their seedlings. It is more difficult to control seed dispersal where the prevailing wind is contrary to the water flow. These conditions prevail at Upper Mohawk and nearby Lake Hopatcong. In view of the general movement of seedlings we have put one cove at the northwestern end of the lake under special observation. This area is nine acres. Due to its location and width of opening to the main lake (200 yards) this area has a lesser chance for reinfection. In 1950 every square foot was covered with Potamogeton crispus and was unusable for recreational purposes. In 1960 this area is usable at all times and an annoying insect problem has been reduced because of the high degree of weed control. For three years we have double treated this area in the manner described with the hope of exhausting the seeds stored in the bottom. In 1960 this area had a very light growth and was treated but once.

Although sodium arsenite controls our main problem, its use creates an obnoxious by-product. The disintegration of the dead weeds sharply raises the bacteria, which in turn are finally reduced to fertilizing elements that support a heavy growth of algae. We rake out as much of the dead weeds as we can through nine beaches and have persuaded many property owners to do likewise. As Lake Mohawk is man-made the lake bottom was formerly farm land and pasture land and carried with it all the nutrients kindred to farming and cattle grazing. We are on a migratory flight line for birds and their fertilizing droppings. Property owners keep their lawns well fertilized and every rain storm washes in more nutrients, organic and inorganic. The evidence of persistent foam indicates that detergents are carrying organic nitrogeneous compounds into the lake. The cumulative effect from these sources and others of nutrient material contribute heavily toward the continued support of weed and algae growth.

In consideration of these factors of lake fertility we altered our algae control program in 1956. We try to run off by natural means as much alga laden water as possible. To maintain a constant run off we control our spillway outlet by the use of six 2 x 6" boards laid flat one on the other, as opposed to the customary gate used in small lakes. As the lake level drops, the top board is removed, thereby assuring a two-inch flow of outgoing water off the top level of the lake where the blue green algae thrives, such as Anabaena and Mycrocystis. In this manner we are able to flush off large quantities of algae and their resultant nutrients. When there is a sharp differential between the daytime atmospheric temperature and cooler air at night, a thermal inversion occurs. The cooler water on top, due to its increased density, segregates temporarily a greater amount of algae in the top water. This is run off if the wind is favorable. When the lake water reaches thermal equilibrium later in the day, the board is replaced to save water. By means of a top water control we are also able to flush off many Potamogeton seedlings that float about during the summer. In a prolonged drought we remove as many boards as necessary to maintain a top water overflow as long as possible. If the drought is of such duration that no water goes over the spillway we can expect an increase in lake fertility and a heavier aquatic growth the following year.

As an algicide we have been using 2,3-Dichloronaphthoquinone (Phygon XL). This is a selective algicide and will not produce, in our opinion, the clarity of water that copper sulphate does, within the fish kill limits. There are certain well established critical temperatures of fresh water that stimulate certain species of algae into activity. We watch for 68 degrees Fahrenheit and 77 degrees Fahrenheit. However, we are not attempting to destroy all algae, as we try to run off as much as possible in suspension. Moreover it protects our fish life. Our costs for algae treatment were formerly higher than the cost for weed treatment. Now algae control expenditures are one-third of the present cost of weed treatment. We must advise that we have to face up to some complaints about algae following the weed kill, but there is an understanding acceptance, in view of the overall objective.

The dichlone is applied by the same equipment as the sodium arsenite with minor changes. We mix fifty pounds of the powder with one hundred gallons of water. The liquid is drawn from the tank by a twenty gallon per minute pump. A "Y" connection is used to direct one outlet approximately 45 degrees off the port stern and the other 45 degrees off the starboard stern. To produce a spray pattern two short lengths of ordinary garden hose with adjustable nozzles are used. An effective mix is obtained when the spray pattern just meets the outer edges of the propeller wash. We use one pound per acre. Control and constant agitation is obtained by adjusting a by-pass valve directing a percentage of flow-back to the tank.

As possibly related to our algae growth, a comment on our coliform count is interesting. Considering the potential possibilities we have of coliform contamination, we are unusually low. We are told by a local bacteriologist, who does our analytical work in this category, that we have the lowest average coliform count of all northern New Jersey lakes that come under his observation - also the highest algae count. This possible relationship is supported by a paper presented at the American Public Health Association on November 3rd at San Francisco, entitled "Controlled Photosynthesis and Public Health", and the National Civic Review July, 1960. The rapid production of oxygen by algae acts as one of natures most powerful purifying agents. This is another reason why we have put limits on our algae kill.

Within the boundaries of the Lake Mohawk reservation, we have a twenty-four acre pond known as Upper Mohawk. This pond is also infected with Potamogeton crispus. Our treatment in this pond is the same as on the main lake. For some reason the plants grow at Upper Lake with less vigor and develop about three weeks later. In 1958 this pond was infected with Myriophyllum spicatum. It spread with great rapidity. By August, 1958, the growth could be seen under water throughout the entire twenty-four acres. On August 20, 1958, we treated with 2,4,5-TP (Kuron) at 2 PPM. The chemical was mixed with fifty percent water in a one hundred gallon tank and was constantly agitated by power. Application was made with an ordinary adjustable garden hose nozzle under light pressure. Every square foot was treated. The shore lines were simultaneously treated with a hand pump from a rowboat. The Myriophyllum was literally nipped in the bud. No evidence of this growth has re-appeared up to 1960. To prove this control, we eliminated all treatment of either sodium arsenite or 2,4,5-TP in 1959. The 2,4,5-TP applied in August, 1958 also sharply lessened the Potamogeton growth in 1959. However, in 1960 the Potamogeton re-appeared and treatment was resumed with sodium arsenite. The 2,4,5-TP does not seem to affect the well established Potamogeton crispus, but apparently does affect the seedlings that float about during the summer. It appears that if the initial infection of Myriophyllum can be destroyed before seeds are deposited and fertilizer in the lake bottom, the eradication is permanent. Of course, reinfection from outside sources may occur at any time.

From our experience it appears that the Myriophyllum family draws a greater quantity of nutrients from water to sustain its growth than the Potamogetons do. We have never seen a sustained heavy algal growth where Myriophyllum thrives. In the case of Upper Mohawk, it could be that the sporadic invasion of Myriophyllum so exhausted the nutrients in the water that the Potamogeton had difficulty in 1959 in finding sufficient food for vigorous growth. We need research in this direction - to find out what plants take what quantity of nutrients from the water to sustain themselves.

It is our belief that the hormone type of weedicide such as 2,4-D and 2,4,5-TP is an all or none proposition. A test area seems to create on its outer periphery a zone of growth stimulation and extends to a point where sunlight no longer penetrates. This does not mean to infer that 2,4,5-TP is superior to 2,4-D. Before 2,4-D was commonly pelletized, we treated a nearby pond with 2,4-D in liquid form at 2% solution. The entire surface of fifteen acres was treated and the results were highly acceptable. The growths varied but was predominantly Anacharis.

The question of lowering the lake to assist in weed control has probably received more comment by property owners than any other facet of this problem. Probably because it is the physical activity most recognizable by most people. From a botanical point of view it could be beneficial provided popular opinion allowed one to lower the water on a botanical timetable rather than a recreational timetable. Certain aquatics flower in August. If the seeds and pollen could be flushed off at that time it would be decidedly advantageous in controlling one phase of plant reproduction. However there are additional means of reproduction other than through flowers. The Potamogeton family, the most numerous of the seed aquatics, produces new seeds through flowers in June. We doubt the public acceptance of this scientifically timed biology should we drain the lake in June.

We first began to pay serious attention to lake fertility during drought periods when no water was going over our spillway and the fertilizing elements of Lake Mohawk water increased. We then examined a swimming pool that recirculated its water for purification. In June the pool was filled with potable water which showed .05 nitrates PPM. By September it had jumped to 8.25 PPM. The algal growth increased proportionately. We then examined the bottom water of a drained lake in several areas. The results showed increased nitrates or a high coliform count, both nutrients that support vegetation. Hydraulic engineers have informed us that when the static pressure is altered, as lowering the lake does then all the elements, organic and inorganic flow by the force of gravity toward the drained area. These will later serve as food for some vegetation growth. Furthermore when a lake is lowered a mass of exposed dead vegetation appears on the receded shore line.

It would be beneficial to remove this material. We have never seen it removed. It becomes a rich compost by Spring. When the lake is filled this shore line compost is already there as a fertilizer.

There is another aspect to be considered. Many owners of lake front property build masonry walls at considerable expense. While it is true that many of the walls are not properly built, the act of lowering the lake increases the risk of winter damage. The water under the ice is obviously above freezing. It is about 38 degrees Fahrenheit. If the protection of this 38 degree Fahrenheit water is removed by lowering the lake, masonry walls are subject to the usual heaving and cracking that a deep freeze creates.

From what has been said it is obvious that we are generally opposed to lowering the lake level, and specifically opposed to it in connection with Lake Mohawk. In northern New Jersey many have watched with keen interest the fine work of Mr. Horrocks, your next speaker, in connection with control activities at Lake Hopatcong. His work has been so convincing that many people at Lake Mohawk have asked why we do not lower our lake as they do at Hoptacong. Mr. Horrocks has unknowingly forced me into a rebuttal.

In conclusion, we find we have independently developed practically the same techniques and obtained the same results as outlined in the report of 1958 published by the Committee of Water Pollution, Madison, Wisconsin. In some respect our approach is different as to rooted and unrooted vegetation. Where these differences occur have been pointed out in this report. Our best progress from the standpoint of exhausting the seed supply stored in the mud has been in the last three years, when double application was made in the manner described - and at lower cost. To what degree we have been able to lower the overall fertility of the lake by lessening the decomposition of algae within the water by chemical treatment cannot be stated with certainty. Although we consistently have the water analyzed to determine one of the main fertilizing agents, nitrates, no clear correlation can be drawn between the growth of vegetation and nitrate content. Nevertheless, we have observed that we no longer have a troublesome second growth of potamogeton in September as we formerly had. This seems to indicate a lessening of fertility.

What we are trying to do at Lake Mohawk is to bring the paradoxical dilemma between the naturalist and the chemist in better alignment. Our belief in the chemical control point of view is supported by the fact that we have spent some $80,000 in making our water more acceptable. We said at the outset that we could be trapped by our own logic and we think we have proved it.

PROGRESS REPORT ON THE FIELD TESTING OF VARIOUS HERBICIDES FOR AQUATIC WEED CONTROL

by

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In recent years, a considerable research effort has been made in determining the potentials of Silvex and Granular 2,4-D formulations as effective aquatic herbicides.

Examination of the literature indicates that Silvex 2-(2,4,5-Trichlorophenoxy)propionic acid,propylene glycol formulation, was found to be highly effective in the control of a large complex of aquatic vegetation, such as: Myriophyllum sp., Nymphaea, sp. Nuphar sp., Brasenia sp., Cabomba sp., Elodea sp., Ceratophyllum sp., Pontederia sp., Sagittaria sp., Callitriche sp., Juncus sp., Typha sp. (1,2,8,10,12).

Similarly,field studies using various formulations of granular 2,4-D have indicated satisfactory results in the control of many susceptible forms, such as: Myriophyllum sp., Cabomba sp., Elodea sp., Nymphaea sp., Nuphar sp., Ludwigia,sp., Trapa sp., (4,5,7,9,11,12).

While Silvex and Granular 2,4-D appear to be effective against a wide range of species, nearly all reports indicate their ineffectiveness in the control of pond weeds, Potamogeton sp.

Since this species and other highly resistant forms, play an important role in the ecology of a weed infested pond, their control is considered to be highly desirable.

Flanagan (1960) reported excellent control was obtained of Potamogeton sp. with Simiazine at 3.0 ppm.(3). A progress report on the use of Aqualin Herbicide by Green (1960) indicated that submerged and floating forms appeared to be susceptible to this chemical (6).

The purpose of this study is to evaluate the effectiveness of certain herbicides for use in the control of aquatic vegetation, with particular reference to species of Potamogeton sp.

PROCEDURE

The chemicals tested in this study were as follows: Aqualin, Endothal, Esteron 99, M-1845, M-1847, Silvex 4L, and Simazine. The active ingredients and the source of these formulations are found in Table I.

TABLE I

DESIGNATION	ACTIVE INGREDIENT	SOURCE
AQUALIN	Acrolein, acryladehyde, 2, propenal	Shell
ENDOTHAL	Disodium 3,6 Endoxohexa-hydrophthalate	Pennsalt
M-1845	Liquid salt of Silvex; 2-(2,4, 5-Trichlorophenoxy) Propionic acid	Dow
M-1847	Granular salt of Silvex 2,(2,4,5-Trichlorophenoxy) Propionic acid	Dow
ESTERON 99	2,4-Dicitrochlorophenoxy Acetic acid	Dow
SILVEX 4L	2(2,4,5-Trichlorophenoxy) Propionic acid, Iso-octyl ester	Chipman
SIMAZINE	(2-Chloro-4-6 bis ethylamino) -3-triazine	Geigy

All field tests were carried out under conditions which were as closely standardized as possible. Areas were carefully screened to insure both ecological and limnological similarity.

Liquid chemical applications were made using a specially designed chemical injection system to insure uniformity of treatment. Initially, granular formulations were applied with a rotary spreader. However, this was found to be inefficient especially in the treatment of back cove areas where manuevrability was limited.

It was then necessary to develop a granular chemical injection system similar to that used with liquid formulations. By introducing the granular material into a stream of water, it was then possible to spray the chemicals evenly over the surface of the area to be treated.

A closed system, utilizing underwater jets, was developed for the application of Aqualin Herbicides.

RESULTS

The effectiveness of the herbicides tested is indicated as the percentage of aquatic vegetation showing discoloration of stem and leaf tissue, cytological decay, and/or complete disintegration.

LIQUID FORMULATIONS

AQUALIN HERBICIDES: A total of six experiments were conducted between June, 1960 and September, 1960. To plots of 1.0 to 3.0 acres, Aqualin was applied at the rate of 3.0 ppm. In all tests, the species of aquatic weeds were the same. *Potamogeton natans*, the predominant form, was controlled effectively with a degree of kill estimated at 90 to 100%; *Utricularia purpurea* 100%; with only slight reinfestation late in the fall from surrounding untreated areas; Algae (filamentous) 100%; *Nymphaea odorata* 20%; *Nuphar advena* 20%; *Brasenia schrebei* 40%; *Polygonum pennsylvanicum*, no results.

ENDOTHAL AQUATIC WEED KILLER: Plots, at the rate of 2.0 ppm, 3.0 ppm and 5.0 ppm, were treated on June 28 and August 25, 1960. Tests conducted in June at 2.0 ppm on plots of 1 acre in size gave only a moderate reduction in the density of the weed growth. Control was estimated as follows: *Potamogeton natans* 50%; *Nymphaea* sp., *Nuphar* sp., *Brasenia* sp., and *Utricularia* sp., were not significantly affected.

Plots, treated in August, 1960 at rates of 3.0 ppm to 5.0 ppm gave excellent control. Effectiveness was estimated as follows: *Potamogeton natans* 90 to 100%; *Potamogeton oaksianus* 90 to 100%; *Utricularia* sp., 100%; Algae 100%; *Polygonium pennsylvanicum* 60%; *Nymphaea* sp.,30% and *Nuphar* sp.,30%.

M-1845 (SILVEX): Tw areas were treated at the rate of 1.0 ppm. One area of two acres, treated on July 27, 1960, was effectively controlled of the following forms of aquatic vegetation: *Myriophyllum heterophyllum* 100%; *Nymphaea* sp., 90%; *Nuphar* sp., 60%, and *Utricularia* sp.,60%.

On August 15, 1960, the first of three treatments was made to a 23 acre reservoir filled with Elodea canadensis. Treatment was made at four day intervals to minimize the possibility of fish kill and undesirable odors. Control was estimated at 95%. No undesirable odors or tastes were exhibited. There was no fish kill.

SILVEX 4L: Treatment was made on July 27, 1960 at the rate of 0.5 ppm. Control of Myriophyllum heterophyllum was excellent and estimated at 100%. Floating forms, however, showed only slight control at this rate. The species and the degree of control were as follows: Nymphaea sp., 70%; Nuphar sp., 30%; Brasenia sp., 30%. There was considerable regrowth of these latter forms noted in September when the areas were resurveyed.

GRANULAR FORMULATIONS

ENDOTHAL 5% GRANULAR: On June 30, two 1.0 acre plots were treated at the rate of 2.0 ppm. The species and degree of control were as follows: Potamogeton natans 90%; Potamogeton Robbinsii 100%; Nymphaea sp., 60%; Nuphar sp.,40%; Utricularia sp., 60% and Polygonum sp., 30%.

ESTERON 99 (2,4-D): Treatment was made to 1.0 acre and 2.5 acre plots on June 27 and July 27 respectively. Application at the rates of 50 lbs/acre produced results as follows: Myriophyllum heterophyllum 100%; Nymphaea sp., 80%; Nuphar sp., 60%; Ceratophyllum demersum 70%; Potamogeton natans, no results.

M-1847 (SILVEX): A 5.0 acre area was treated on June 29, 1960 at the rate of 50 lbs/acre. Granular salt of Silvex produced excellent results in clearing the area of the following forms: Nymphaea sp.,100%; Nuphar sp., 100%; Ceratophyllum demersum 100%; Utricularia purpurea 80%.

SIMAZINE 4G: While only one test was conducted with this material, and that being only 0.75 acre in size, it was felt however that the results against Polygonum pennsylvanicum were somewhat significant. Control of this species was estimated at 80% of the original population.

DISCUSSION:

Field studies of the various herbicides tested indicate clearly that some formulations are more effective in dealing with one aquatic weed problem than another. It is also significant to point out that no one chemical was effective against all species of aquatic vegetation treated.

Aqualin Herbicide proved to be extremely effective for use in the control of certain resistant species, such as Potamogeton sp. However, Aqualin did not appear to effectively control many floating and emergent forms. The major drawbacks to the wide spread of this material lies in its highly volatile nature. Since the chemical causes lacrimation when exposed to the unprotected eye, a closed system must be maintained during all phases of the application. Considerably more work must be done in the development of safe handling techniques if Aqualin Herbicide is to have wide spread use in aquatic weed control.

Both granular and liquid formulations of Endothal, appear to be highly promising for the control of pond weeds, Potamogeton sp., Nymphaea sp., and other emergent forms, did not respond as well as did the submerged species. The only difference between the two forms of this material was that the liquid formulation produced a generally dispersed pattern while granular Endothal was more localized in its effect.

Experimental formulations M-1845, Silvex, produced excellent results. Since there were no species of Potamogeton in the pond treated with M-1845, no comparison can be drawn with the other formulations tested. However, its effectiveness in the control of Elodea sp. and Nymphaea sp., coupled with its relatively low toxicity to fish, make it a highly desirable material for use in watershed and reservoir areas. It is apparent that additional work along these lines should be undertaken.

Experimental formulation M-1847, Granular Silvex, was not only highly effective but also safe and easy to handle. Its wide range of susceptible species indicates that additional w rk should be done to accurately determine its ultimate potential.

It would be difficult, because of the limited number of field tests conducted, to evaluate the results obtained with the other materials tested. It appears, however, that the results clearly indicate that each of these formulations have a definite range of weed susceptibility.

Since there is a wide variety of aquatic weed problems, it appears that the type of control suited for one species may be entirely unsuited to another. The results obtained in this comparative field study, and information now available on other herbicides, clearly indicated that while no one chemical can resolve all problems, certain combinations, specifically combined, can ultimately be an answer to effective aquatic weed control.

SUMMARY

1. Aqualin herbicide was found to be effective in the control of Potamogeton sp., and other resistant forms, however, the material was difficult to handle.

2. Endothal liquid and granular formulations were successful in controlling pond weeds and other forms. They were not effective in the control of certain floating and emergent species.

3. M-1845 and M-1847 were both effective against a wide range of species. Both materials should be examined further.

4. Silvex 4L, iso-octyl ester, responded similarly to propylene glycol formulations in producing excellent control of Myriophyllum sp.

5. Esteron 99 failed to control pond weeds, but appears to be effective against certain submerged and floating forms.

6. Simazine was effective in the control of Polygonum sp.

7. Combinations of chemical appear to be logical approach in areas where varied susceptibility occurs.

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A Study of the Effect of the Weed-Killer, 2, 4-D Aqua Granular on Six Experimental Plots of Long Pond, Dutchess County, N. Y.

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The purpose of this study was to compare the results upon six experimental plots after each had been treated with different concentrations of 2, 4-D Aqua Granular. Observations were made not only of the effect upon the pondweeds, but also of the effect upon plankton and the benthic forms. The duration of this study was from May 25 to September 20, 1960.

Again I wish to thank Mr. John Gould of the New York State Department of Conservation for his continued encouragement and practical aid. For the third summer, Mr. Otto Johnson has graciously given me the use of his boats. The Dow Chemical Company provided me with a small grant which covered mileage expense, student help, and the purchase of 2 new pieces of apparatus. Thanks to this grant, the Zoology Department of Vassar College did not need to stretch its budget so far for me this year, but it always helped when necessary. The Diamond Alkali Company provided the 2, 4-D Aqua Granular or Crop Rider.

Since the conditions in Long Pond have been described in detail (Pierce 1958, 1959, 1960)* only a brief comment upon the plots studied during the summer of 1960 will be made. A series of six plots (50 X 50 ft.) was staked out along the west shore with intervals of 25 feet between the plots. The series was located within the shallow littoral zone (1-3 feet) which, for the most part was choked with a dense growth of floating and submerged pondweeds. The bottom consisted of a deep (oar's length and more) layer of soft mud and decomposing plants. The dominant floating plant was <u>Nymphaea odorata</u>, which covered completely the surface of two plots. The most abundant submerged plant was undoubtedly <u>Utricularia purpurea</u> which formed a thick mat over the bottom of the plot. Included in this dense and tangled mat in scattered patches were, <u>Chara</u>, several species of <u>Potamogetons</u>, and the moss <u>Drepanocladus</u> which formed a thick border very close to the shore line.

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* Pierce, 1958. 12 Ann. Meet. Northeast. Weed Control Conf. 338-343.
1959. 13 Ann. Meet. Northeast. Weed Control Conf. 310-314.
1960. 14 Ann. Meet. Northeast. Weed Control Conf. 472-475 and 483-487.

The control plot was chosen somewhat south of the experimental area, at a distance great enough to be unaffected by diffusion.

Between the dates June 8-10, preceding the application of the Aqua Granular on June 29, preliminary observations were made and sampling was carried out. After the application, this routine of observation and sampling was repeated at intervals throughout the season, namely July 1, July 5, July 20, and September 15. Samples were taken at random from each plot and the control. In each plot the bottom temperature was recorded, a water sample from the bottom was obtained, and two hauls for benthic organisms were made with an Eckman dredge. A plankton haul was also made and standardized as well as possible by rowing 3 times across the plot. The contents of the dredge were sieved, identified, and counted in the field. The plankton was taken directly to the laboratory where it was identified under a binocular dissecting microscope. The water samples also were carried immediately to the laboratory where determinations of pH and O_2 in ppm were made by the use of the Hellige Testing Apparatus.

On June 29, the Aqua Granular was applied by hand from a rowboat. As the granules were scattered from the boat, most of them sank slowly to the underlying weeds, or fell to the bottom mud if that was uncovered. Some granules remained on the lily pads for a day or two but eventually fell into the water. Granules were obvious in the water for 4 or 5 days and some were visible even a week after the application.

The six experimental plots were treated as follows. Three plots received granules of 10% 2, 4-D acid equivalent, at a concentration of 0.9 ppm, 1.3 ppm, and 1.8 ppm. The other three received granules of 20% 2, 4-D acid equivalent at a concentration of 1.8 ppm, 2.6 ppm, and 3.6 ppm. In both series the bulk rate was 50 lbs./acre, 75 lbs./acre and 100 lbs./acre.

Since the immediate results of the application of the granules were similar for all plots, a general description appropriate for all will be given. On the first day after the application, the typical reaction began. Lily pads developed brown spots and began to curl; flowers looked wilted; petioles appeared slightly longer. On the second day, the reaction was intensified. The lily pads were curling, and due to the elongated petiole, overturning. By the sixth day, the pads and stems presented a tangled mass of vegetation. The numerous elongated and arched petioles together with the overturned pads gave a definite red cast to the plots. Both stems and leaves were decaying rapidly. At this point it was obvious that Nymphaea and Brasenia had received lethal doses of 2, 4-D. However, no opinion on the condition of submerged vegetation could be advanced.

By the end of three weeks, the surface of the plots was partly cleared by the natural decomposition and sinking of the vegetation. This clearing process could easily be hastened by raking and removing the dead plants. The borders of the plots were precisely outlined by the flat green pads of the untreated surrounding area. Even the corners were accurately defined. This would imply that little diffusion of the 2, 4-D had occurred. All plots showed the destruction of Nymphaea and Brasenia. The two plots receiving the largest doses, D-20-75 and D-20-100, exhibited extreme conditions. The decomposition occurred more rapidly and more intensely.

As for the submerged plants, it was as always, very difficult to make a decision. In the dredges, many living weeds (Chara, Utricularia and several Potamogetons) were still present. In fact, the Utricularia possessed conspicuous bright green growing tips. The carpet of dense vegetation on the bottom was definitely still present and growing.

The next sampling date was September 15, eleven weeks after the application of the pellets. During late July and August, the surface of all plots had become clear of lily pads and remained so for the season. The borders and corners of several plots were still very precisely outlined and obvious to even a casual observer. In plots where low concentration of 2, 4-D had been used, (0.9 ppm and 1.3 ppm) a very few new leaves of Nymphaea were sprouting in scattered patches. However, in all the other plots no regeneration was noticed. In brief, all concentrations used were effective in clearing the surface of Nymphaea and Brasenia for the season.

As for the submerged plants, it can be said that the dense carpet of Utricularia and Chara was diminished and restrained, but not eradicated. A comparison with untreated surrounding areas did show a reduction in the mass of vegetation which is held far below the surface of the water, instead of occupying every inch from bottom to surface. The moss Drepanocladus appeared to be entirely resistant to 2, 4-D granules and showed no retardation in growth or reduction in abundance.

It is suggested that the low concentrations used were sufficiently strong to clear the surface of floating weeds, and that possibly even lower concentrations might well be effective for these species.

Since the summer of 1960 was a relatively cool and sunny period, no extremes of temperature were recorded either for the air or the water. From June 8-September 20 the variation in the pond followed the expected seasonal trend. Throughout the month of June the temperature of the water remained constantly at 71°F. By July 1, it rose to 74°F, and increased to 78°F by July 20. By September 15, it had dropped to a seasonal 68°F.

The dissolved oxygen content reflected in general the seasonal trend of temperature, both in the control and experimental plots. The control was consistently the lowest, ranging from 5.5 ppm on June 8, to a low of 4.0 ppm on July 20, and returning to 7.5 ppm on September 15. Within the experimental plots the same trend was apparent, but the variation occurred over a wider range. On June 8 a reading of 8.0 ppm was common, decreasing to 4.0-6.0 ppm by July 20, and returning to 8.0 ppm by September 15. There appeared to be no correlation of dissolved oxygen content with different concentrations of weedicide in the plots.

The pH readings, although reflecting slightly a seasonal change were remarkably constant. In both control and experimental plots the readings usually fell between 7.2-7.6. Only during late July when temperatures were high and O_2 ppm low did the pH fall to 7.0 in the control and two of the experimental plots. No correlation of pH with different concentrations of the weedicide can be established.

The plankton identified can be conveniently grouped with the same divisions as in previous years: Myxophyceae; Chlorophyceae (including desmids and diatoms); Protozoa; Rotifera; Annelida; Crustacea (Copepoda, Cladocera, Ostracoda, and Amphipoda); Insecta (larvae or nymphs of Mayflies, Damselflies, Dragonflies, and Diptera); Gastropoda; and Arachnida (many mites). Again as last year, there were 50 commonly occurring species large enough to be identified by the low power of the compound microscope, and many additional tiny forms. The constant occurrence of the same organisms over and over again was monotonous to identify. Out of the 27 hauls made, three forms, <u>Arcella</u>, <u>Micrasterias</u> and <u>Ceratium</u> occurred every time. Many other forms occurred 25 out of 27 times. No accurate quantitative studies were attempted because of the difficulties of precise collecting. However, any qualitative seasonal variation was reflected by control and experimental plots alike.

Within the first 2 days following application of the granules, however, the plankton population of all experimental plots appeared to be "sick". While it is very difficult to describe this condition, especially since there was no quantitative data as proof, the general description is as follows: In all plots, but especially at concentrations of 2.6 ppm and 3.6 ppm, there was a decrease in the phyto plankters, namely the green filamentous and coccus forms and the blue green filamentous. In the large finger bowls, there were fewer lively active crustacean forms, which were usually very abundant and easily seen. In general, a little of everything survived, but the representation in abundance was poor. Many plankters from the experimental plots died in the finger bowls after two or three hours, while those in the control survived as usual until the following day. It should be mentioned that during these first few days after application, undissolved granules were often collected with the plankton, and thus the plankton may have been living in extremely high concentrations of 2, 4-D for the hours immediately following their collection.

By the eighth day after application, a decided "improvement" was noticed in the plankton samples, and by the next sampling date (unfortunately three weeks) all samples resembled the control. It is possible, therefore, that the presence of 2, 4-D granules in relatively high concentration does reduce the plankton population at least temporarily.

At all times throughout the 1960 season, large aquatic vertebrates such as turtles, frogs, and fish were present and vigorous in the treated plots as well as the control. Many schools of small, young fish, (1-1½") were observed swimming actively in and about the weeds.

The benthic organisms dredged and identified in 1960 were members of the same large groups as in previous years. These groups were: Annelida (leeches and oligochaete worms); Gastropoda (several genera, Amnicola, Helisoma, Physa and Valvata); Pelecypoda (Sphaerium); Amphipoda (the common scud); Isopoda (Asellus); Insecta (larval stages of Mayfly, Damsel fly, Dragonfly, and Midge). Both control and experimental plots showed a seasonal fluctuation. For example, the number of Mayfly larvae counted in June and in September was 10/dredge, but in late July this rose to 50/dredge. The number of Valvata tricarinata counted in June was 2/dredge, whereas in September the count was 80/dredge. In no sample did any one group show any significant variation from the seasonal fluctuation exhibited by the control.

Summary

1. Six experimental plots (50 X 50 ft.) were selected along the west shore line of Long Pond.

2. The observations on these plots were made from May 25-September 20, 1960.

3. Preliminary study of the following conditions and organisms was carried out on June 8: bottom temperature, pH, dissolved oxygen content, plankton and benthic forms, large aquatic vertebrates, and pondweeds. The same routine of study was repeated on July 1, July 5, July 20, and September 15.

4. The six experimental plots were treated with different concentrations of 2, 4-D Aqua Granular (Crop Rider). These concentrations ranged from 0.9 ppm, 1.3 ppm, 1.8 ppm, 2.6 ppm, to 3.6 ppm.

5. The periphery of each experimental plot was precisely defined by the surrounding untreated green area. This implies that diffusion of the granules from the plot is negligible.

6. Nymphaea odorata and Brasenia sp. were successfully eliminated by all concentrations.

7. Utricularia purpurea was definitely reduced but not eliminated by concentrations of 1.8 ppm, 2.6 ppm, and 3.6 ppm.

8. The temperature of the bottom water varied between 68°-78° F.

9. The pH fluctuated from 7.6-7.0, and varied as did the control.

10. The dissolved oxygen content fluctuated from 8 ppm in both June and September to a low of 4 ppm in mid-summer. Treated plots varied with the control.

11. Plankton was constantly represented in both control and experimental plots by the same forms as in previous years. During the eight days after treatment, both the activity and numbers of the population appeared reduced. By the end of three weeks, the population had regained its original condition before treatment, and similar to the control.

12. Benthic forms were constantly represented by forms identical with those of preceding summers. Their numbers were not effected by treatment. They varied as did the control.

13. Fish of all ages, frogs, and turtles were present and vigorous in both treated and control areas.

Progress Report on the Effect of Kuron Applications after One and Two years at Long Pond, Dutchess County, New York.

Madelene E. Pierce, Vassar College, Poughkeepsie, New York.

The purpose of this paper is to make brief comments upon the condition, in 1960, of experimental plots treated with Kuron in 1957 and 1958 *(Pierce, 1958, 1959, 1960). A two acre plot, treated in 1958 with a concentration of 2 ppm, was successfully cleared of Nymphaea, Nuphar and Pontedaria and remained clear for the entire season. In June 1959, the surface was still practically clear of these weeds except for a few scattered plants of Nymphaea and Nuphar. The area was again treated with a concentration of 1.2 ppm. The scattered plants succumbed quickly and the surface remained clear of them for the entire season. During the summer of 1960 no further treatment was given to these two acres. However, the surface of the area remained clear and not a pond lily pad was present throughout the season.

The effect of the applications in 1958 and 1959 upon the submerged weeds was not so successful. By the summer of 1960, Utricularia was still definitely reduced, especially in shallow areas, but not eradicated. Potamogeton amplifolius and P. natans were flourishing in the deeper areas.

In June of 1957 (Pierce, 1958) two small plots were twice treated with Kuron. The first application was on June 8 at a concentration of 0.8 ppm, and the second on June 29 at 1.3 ppm. As a result the Nymphaea was eradicated and remained so for that season. In the spring of 1958, these plots were not selected for experimental work, but as a favor to the land-owners, were given a heavy (not measured) spraying. As a result, the Nymphaea was eradicated for the entire season, and the Utricularia was checked in growth. By June 1959, this portion of the shore-line was vastly improved. The surface was clear of pads for the season and the submerged Utricularia was reduced. No further application was made in 1959. During the summer of 1960 this area remained clear of Nymphaea, and Utricularia also remained reduced if not completely eradicated. No further treatment was given in 1960.

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* Pierce, 1958 12th Ann. Meet. of the Northeast Weed Control 338-343
Pierce, 1959 13th Ann. Meet. of the Northeast Weed Control 310-314
Pierce, 1960 14th Ann. Meet. of the Northeast Weed Control 472-475

A PRELIMINARY REPORT ON THE EFFECT OF SOME AQUATIC HERBICIDES ON WATER QUALITY[1] (Abstract)

by Samuel D. Faust[2], Robert J. Tucker[3], and Osman Aly[4]

Ester derivatives of 2,4-dichlorophenoxy acetic acid and 2(2,4,5-trichlorophenoxy) propionic acid have proven to be successful aquatic herbicides. There are, however, several questions to be answered concerning the effect of these compounds and their commercial formulations on the quality of a potable water supply. Among these questions are the following: Are there objectionable tastes and odors imparted to the water? Do the commercial formulations effect the chlorine demand of the water supply? Do these organic compounds of phenolic origin release free phenols to the water? If so, what are the mechanisms of release of these free phenols and how long do these compounds persist? A report is offered, herewith, that provides preliminary answers to these questions of the effect of aquatic herbicides on water quality.

Various concentrations of two granular and one liquid formulation of esters of 2,4-dichlorophenoxy acetic acid and one liquid formulation of an ester of 2(2,4,5-trichlorophenoxy) propionic acid were added to 15 liter portions of a lake water. Each herbicide was added in concentrations of 1,5, and 10 mg/l either as their acid equivalent or as their ester equivalent. Thereupon these treated portions of water and a control system were stored in five gallon carboys at room temperature. Periodically these systems were examined for threshold odor, chlorine demand, and free phenol content. All analyses were made in accordance with the 10th edition of "Standard Methods for the Examination of Water, Sewage, and Industrial Wastes", American Public Health Association, 1955. In addition, the phenols were also determined by another method described later in the report.

It was found that all four aquatic herbicides imparted objectionable odors to the water at the three concentrations examined. The qualitative description of the odor was a function of the herbicide carrier in the commercial formulation. These odors were described as aromatic (kerosene or fuel oil carriers) or musty (solid clay carriers). The average threshold odor values ranged from 25 to 250 and, in general, these values remained constant in all systems for storage periods ranging from 50 to 75 days.

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The 15 minute, 0.1 mg/l residual chlorine demand was, in general, increased by the liquid and granular herbicide formulations. When the increase in chlorine demand was expressed as percent of the control, it was found to be a function of the type of formulation, concentration of the herbicide, and period of storage. In general, the liquid formulations produced higher chlorine demands for a given herbicide concentration than the granular formulae. In addition, a percentagewise increase in the chlorine demand was observed in the liquid formulated systems as the concentration of the herbicide was increased from 1 to 10 mg/l. The chlorine demand of the liquid carrier systems showed an increase followed by a decrease during a 74 day storage period. Neither the herbicide concentration nor length of storage appeared to affect the percentage increase of the chlorine demand produced by one of the granular formulations. In this system, the chlorine demand increased by 50 percent and persisted for 50 days in the 1, 5, and 10 mg/l herbicide systems. The second granular formulation showed an increase followed by a decrease in chlorine demand during a storage period of 50 days.

Significant amounts of 2,4 dichlorophenol and 2,4,5 trichlorophenol were found in all experimental systems. It was discovered in the course of the investigation that the 4-amino antipyrine colorimetric method offered by the 10th edition of Standard Methods does not quantitatively detect para-substituted phenols. The prescribed pH conditions of 10.0-10.4 do not permit the 4-amino antipyrine-phenol complex to develop color. Thereupon, the method was modified to pH conditions of 8.0$\pm$ 0.1 where the para-halogenated phenols developed maximum color. Consequently, higher phenol concentrations were found in the herbicide treated waters than initially indicated by the unmodified method. For example, a water treated with a 1 mg/l acid equivalent concentration of an ester formulation of 2,4-D showed a 2,4 dichlorophenol concentration of 58.2 ppb after 14 days of storage by the modified method as against a 0.0 ppb phenol concentration by the unmodified method.

The concentration of the free phenolic contamination was found to be a function of initial herbicide dosage and the type of formulation. The free phenol concentrations imparted to the water by the liquid formulated herbicide generally increased during a storage period of 140 days. On the other hand, the phenol concentration that resulted from the granular 2,4-D formulations generally decreased during a storage period of 92 days. For any given system, the phenol concentration increased as the herbicide dosage was increased from 1 to 10 mg/l.

It is suggested that there are three mechanisms responsible for the release of free phenols from the 2,4-D and 2(2,4,5)-TP herbicides. They are as follows: (1) a free phenol impurity present in the formulation as a result of the manufacturing process, (2) chemical hydrolysis of the organic esters in water, and (3) biological degradation of the ester portion of the herbicide. Several commercial formulations of the 2,4-D herbicides were found to contain trace quantities of free 2,4 dichlorophenol. Likewise there is evidence from this investigation that either slow chemical hydrolysis or biological degradation of the ester compounds releases free phenols to the water. These latter two mechanisms, therefore, would account for the observed increase of phenol concentration with prolonged storage in the liquid formulated systems.

CONTROL OF EURASIAN MILFOIL, *Myriophyllum spicatum*, in LAKE HOPATCONG, NEW JERSEY

Amos W. Horrocks

Roland F. Smith[1]

INTRODUCTION

When Lake Hopatcong was surveyed by the Division of Fish and Game in 1950, (Renlund, 1950), thirty-six species of rooted aquatic plants were collected. None was considered a nuisance, though one species identified only to the genus *Myriophyllum* was recorded as occurring "frequently." No one could foresee its increase to where it would greatly restrict the lake's recreational use, and conseouently become a serious detriment to the many businesses surrounding this largest and most popular of New Jersey lakes.

By 1957 milfoil was occurring in sufficient abundance to cause complaints from lake front owners and boating enthusiasts. Test plots to evaluate the effectiveness of some of the newer herbicides were set up during the summers of 1957 and 1958, (Younger 1959)[2]. By 1958 fishermen were more frequent in adding their voice to the complaining groups and the weed problem had reached serious proportions.

In the Fall of 1958 Commissioner Salvatore A. Bontempo, head of the Department of Conservation and Economic Development, appointed a group of local citizens to the Lake Hopatcong Advisory Committee. State personnel were assigned as consultants to this committee. The weed situation was one of the first problems taken under consideration by this committee and recommendations were made for active state support.

1/ Conservation Officer and Principal Fisheries Biologist, Division of Fish and Game. Fisheries Research and Development Section, Bureau of Fisheries, Misc. Report #23.

2/ This work was financed by Federal Aid to Fish and Wildlife Funds, Dingell-Johnson.

In July of 1959 funds were made available by the State Legislature to the Department of Conservation and Economic Development for the control of aquatic weeds in Lake Hopatcong. However, it was felt that an all out program was too premature for the 1959 season so water-front owners were encouraged to undertake their own weed control. The Lake Advisory Committee, working with the Division of Fish and Game, acted as consultant and coordinator to those interested in doing this work; they also attempted to exert some control over the type of chemicals that were applied and the commercial applicators contracted for the work.

Additional test plots were set out in preparation for the large scale operations to be undertaken by the State. Detailed surveys of the distribution and composition of the weed beds were initiated in the Fall of 1958, 1959, also in the Spring of 1960. This enabled us to determine the magnitude of the problem and to evaluate the effectiveness of the various herbicides being employed.

These surveys revealed that approximately 40% of the lake's 2,685 acres was infested with weeds, most of which was milfoil, *Myriophyllum spicatum*,3/. Next in abundance was pondweed, *Potomogeton amplifolius*. During 1958 and 1959 about 25% of the lake area was barely usable because of the severe infestation of milfoil.

ACKNOWLEDGMENTS

The success of this project is largely attributed to the wonderful cooperation and interest shown by so many individuals, organizations and other interested groups. Mr. Tom Haigh, Chief, Forest and Park Section, was consulted throughout our entire program; Mr. James K. Rankin, Chief Engineer, Bureau of Navigation, was a most efficient procurement officer. The marine police at Lake Hopatcong and the Lake Hopatcong State Park provided both personnel and equipment.

We also wish to acknowledge the assistance of technical representatives from most of the Agricultural Chemical Companies located in New Jersey. We are particularly grateful for the help

3/ This species was identified by John H. Steenis, Patuxent Wildlife Research Center, Laurel, Maryland, and John Gallagher, Amchem Chemical Company.

received from Messrs. John Gallagher and Harold Collins of the Amchem Company, Ambler, Pennsylvania. Members of the Lake Hopatcong Advisory Committee gave much of their time to this program. We especially wish to acknowledge the services and cooperation of Mr. Emil Hermann, Chairman of this Committee.

We are also grateful for the very active support received from Commissioner Salvatore A. Bontempo; Kenneth E. Creveling, Director, Division of Planning and Development; and Dr.A.Heaton Underhill, Director, Division of Fish and Game. Finally, we are most appreciative of the many newspapers who reported our work in such favorable light.

METHODS AND PROCEDURE

The sampling of the bottom of Lake Hopatcong in 1959 was accomplished with an Ekman dredge and grapple hook. In the spring of 1960 a Raythyon fathometer, model DE119B, was employed with considerable success in connection with Ekman dredge, grappling hook and Scuba equipment. For the most part, weed beds could be easily distinguished; Potomogeton amplifolius, was easily recognized because of its height.

The treatment of the entire infested areas with herbicide could have proven extremely costly. Fortunately, Lake Hopatcong can be partially lowered and the decision was made to attempt to control the milfoil in the shallow areas by freezing.4/ It was decided to lower the lake 7 feet for this purpose. The remaining areas of infestation---mostly between the 7 and 14 foot contour lines---would be treated with 2,4-D granules---about 750 acres.

A thirty-foot barge with an eight foot beam was made available to the project by the Bureau of Navigation. A twelve by two-foot platform was secured across the stern, at each end of which was mounted a Gerber Seeder. These were powered by two 12-volt batteries which lasted approximately twenty hours before requiring a recharge.

4/ Mr. Tom Haigh, Chief of the Forest and Parks Section, had had considerable success in the control of milfoil in some of the state-owned lakes with this technique. The procedure developed is to allow the exposed bottom to freeze to a minimum depth of four inches. Subsequent seed growth normally does not attain sufficient height to be a problem in the same season.

The barge was run at a speed of 8 mph with the seeder hoppers open to #11 setting. At this speed and setting the time to distribute 100 pounds of 20% formulation over one acre was two minutes and fifty seconds. The swath of the two seeders was about thirty feet using Amchem Aqua-Kleer granules 8-15 mesh, and about twenty feet with the 20-40 mesh granular material. Table I presents some additional calibrations.

Table I. Calibrations for the Gerber Seeder

Boat Speed (MPH)	Mesh-size of Granule	Hopper setting	Lbs.	Active Ingredient %	Time to distribute
8.	8-15	11	100	20	2 min. 50 sec.
4.	8-15	12	200	10	5 min. 38 sec.
6.6	20-40	10	100	20	2 min. 44 sec.

Note: Based on two Gerber seeders using Amchem granules.

A crew of three men was required on the barge, the operator plus two men to feed the hoppers. A fourth man was stationed on shore to direct the course of the barge. A flat-bottom, square-bow, sixteen foot aluminum boat was used to treat the shallow areas not affected by the freeze. It was powered by a 10 HP outboard motor and had one seeder mounted on the bow.

The application of chemicals was started the 19th of May, but full-scale applications did not get under way until early June. The milfoil was treated in all developmental stages from vegetative sprout growth to near maturation.

Plots that could be treated in one day's work were marked with 16 foot, 1" x 2" poles topped with colored flags. Styrofoam buoys anchored with sash weights were used where hard bottom conditions existed. These markers were placed on the 7 and 14 foot contour at thirty-foot intervals when the 8-15 mesh granules were used, and at twenty-foot intervals when using the 20-40 mesh granules. The swath of the seeders using different size granules controlled the placement of the markers.

It had been assumed that the diffusion of the chemicals was only five to ten feet, thus keeping the barge on a course sufficiently true to remain within this margin of tolerance proved to be a serious obstacle. The final solution was to use two walkie-talkie radios; one was given to the barge operator, and the other to a man on shore. The person on shore could line the barge with any given marker and advise the operator the course to follow.

It had been expected that where the bottom had been exposed, seed germination would create a problem by late summer, at least in local areas. Plans called for treating these areas with both granular 2,4-D and Silvex.

RESULTS

1. Evaluation of the Weed Control Program:

The main objective was control of the milfoil. In this respect the program must be considered an unqualified success. By mid-August, checks in the lake proper indicated that live strands of milfoil were all but non-existent. In contrast, a private lagoon development contiguous to Lake Hopatcong, where no treatment was undertaken, remained badly infested.

There was no evidence of regrowth or seed germination in those areas where the bottom had been exposed and frozen. We have no explanation for this except to note that there appears to be a greater diffusion of herbicide from large treated areas than has been generally assumed. For example, half of a sixty-acre cove was set aside as a control and left untreated. The other half, plus approximately 290 acres adjacent to this cove was treated at the rate of 20 pounds active ingredient per acre. All of the milfoil, including that in the control area disappeared over a three week period.

Where there was inadequate draining of the exposed bottom area, leaving shallow pools, no control by freezing was obtained, necessitating herbicidal treatment. Apparently, the water under the ice acted as an insulation, protecting the milfoil from freezing. It was observed that fragments were trapped in the ice and as the lake level was raised, they broke loose to reinfest other areas of exposed bottom. These infestations also appear to have been controlled by diffusion from treated areas.

The effect of the hormone could generally be seen after about 6 days, when the tops of the milfoil would start to collapse. Within two weeks the stems were defoliated and lying on the bottom; after about three weeks little trace of the plants could be found.

No significant control of any of the Potomogetons nor of the tape grass, Vallisneria americana, was observed. Many of the areas successfully treated in 1959 were taken over by tape grass and this plant also succeeded the milfoil during 1960. This had been expected since Younger (op.cit) reported tape grass succession in plots where milfoil had been successfully controlled.

During the latter part of the 1960 season tape grass became so abundant in some sections of the lake as to become a serious nuisance. Since this condition prevailed during late summer and was far less extensive covering about 250 acres, the magnitude of the problem never reached that created by milfoil.

2. Side effects:
   a. Water color
      During the summers of 1958 and 1959 Lake Hopatcong achieved a clarity that had not been seen in years; the visibility disk disappeared at a depth of 23 feet during August 1959. In 1950 the visibility disk disappeared at depths ranging between 6 and 8 feet; during the summer of 1954 visibility disk readings up to 14 feet were recorded.

      It had been predicted that if the weed control program was successful the water clarity in 1960 would be appreciably reduced.5/ Observations during the 1960 summer season did indicate a greater coloring of the water. Comments also were received from skin divers to the effect that underwater visibility was much reduced from previous years. In support of this is the recording of a visibility disk reading of 9.5 feet on August 24th.

      To what affect these changes may alter conditions for fish life has not been determined.

   b. Taste and odor:
      The 2,4-D granules are known to be contaminated with

5/ Aquatic plants obtain most of their nutrient salts from the water. Where they occur in abundance they may effectively compete with the microscopic plants (algae.) The control of rooted aquatics in farm fish ponds by fertilization to stimulate algae--thereby shading out the rooted plants--will often have the opposite effect if the fertilizer is applied after the rooted aquatics have started their spring growth. Rooted aquatics also serve as effective collectors and settlers of silt and other suspended materials. Finally, particles of decomposing plant tissue will be carried up into suspension by wave action, thereby giving added turbidity to the water.

phenols. While the possibility of Lake Hopatcong water acquiring an objectionable taste or odor was not considered to be important, this could be a serious factor for lakes and impoundments used for water supply.

In an attempt to evaluate this factor arrangements were made with the State Health Department to check for phenols. Water samples were collected under a variety of conditions, preserved with copper sulfate, and delivered to the State Laboratory. None of these samples was found to contain sufficient traces of phenols or phenol derivatives to impart an objectionable taste to drinking water.6/ However, samples collected and analyzed by Dr. S.D. Faust at Rutgers University indicated the presence of phenols in concentrations sufficient to impart an objectionable taste to the water.7/ In support of this we have a few reliable reports from residents at the lake who reported detecting a medicinal odor in Hopatcong water used to make tea.

c. Affect on fish life:
There was no evidence of a single fish having been killed as a result of the herbicide program. No complaints were received of objectionable tastes in the fish; a few fishermen claimed that fishing dropped off for a time where the herbicides were introduced.

Two causes of concern are the possible effect on game fish from the lowering of the lake and the destruction of pickerel spawning habitat.

Evidence at Lake Musconetcong and elsewhere suggest that a properly conducted drawdown can actually improve fishing, especially for yellow perch and pickerel. Whether or not the drawdown in Lake Hopatcong will destroy too much pickerel spawning habitat has not as yet been determined. Checks during the past summer revealed poor

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6/ Personal communication from John J. Nelson, Chief, Bureau of Chemistry, State Department of Health. The Gibbs method was employed in these analyses.

7/ Personal communication from Dr. Faust, Department of Sanitation, Rutgers University. It should be pointed out that the samples collected for analyses by the State Department of Health and Rutgers University were not collected simultaneously though under essentially the same conditions.

pickerel spawning success, but this occurred in neighboring lakes where nothing was done to the habitat.

SUMMARY AND CONCLUSIONS

1. In recent years, at least a fourth of the area of Lake Hopatcong had been rendered useless for boating, swimming and fishing because of heavy infestations of milfoil, Myriophyllum spicatum.

2. A combination of winter drawdown to freeze the exposed plants, and application of 2,4-D granules has effectively controlled this plant. Present observations suggest that this control will be adequate for at least two seasons.

3. Tape grass, Vallisneria americana, has succeeded much of the milfoil, and may reach nuisance proportions. The fact that this condition is much more localized and occurs only during the latter part of the summer makes this a problem of much less magnitude than that presented by milfoil.

4. Pondweeds did not increase during the past year and the evidence suggests that they will continue to be at least as abundant as in the past. To date this infestation has not reached serious proportions.

5. Present evidence suggests the possibility of phenol contamination from the use of at least some of the commercially produced 2,4-D granules. This problem warrants further study.

RECOMMENDATIONS

1. A winter drawdown of Lake Hopatcong to a depth of eight feet is recommended for 1960-61 in an attempt to control the tape grass. Additional drawdowns will be recommended whem necessary.

2. Herbicidal control of the more dense growths of tape grass and pondweed should be attenpted. This will require some additional field testing with chemicals which appear to have a greater herbicidal effect on these plants than does the 2,4-D granules.

3. Spring and fall surveys should be continued to keep abreast of changes in composition and distribution of the rooted aquatics. This will enable us to plan for the next season's weed control program and evaluate the results of current operations.

4. Checks to evaluate any changes in the fish population should be continued. These include rotenone sampling in selected coves, and the complete census of ice fishermen now in its eleventh year.

5. A full time technician or biologist will be needed if the program outlined above is to be carried out. Summer personnel will need to be employed to assist in the field program. In addition to the work at Lake Hopatcong, this person would be able to undertake investigational herbicide projects, coordinate the field research programs of chemical companies wishing to test new products in New Jersey, and conduct extension activities on lakes throughout the State. The latter is a service that is coming into increasing demand in our state.

6. Fish and Game funds are inadequate to support the above program. Since a great deal of the proposed extension work would take place on private waters where Fish and Game monies cannot be spent, it is recommended that a modest appropriation be made from general funds on an annual basis.

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Control of the Pondweed, *Potamogeton crispus*, in both Flowing and Static Situations with Endothal[1]

J. Curtis Simes, Regional Fishery Manager
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An extremely heavy infestation of aquatic vegetation in the earth-bottomed ponds and raceways at the Pennsylvania Fish Commissions' Pleasant Gap Fish Hatchery has for many years made it necessary for hatchery workers to conduct periodic manual weed control operations. Normally by early June the small bass rearing ponds are completely filled with growths of curly-leaved pondweed, *Potamogeton crispus*; common water weed, *Anacharis canadensis*; duckweed, *Lemna minor*; and several species of filamentous algae. The water supply for the hatchery comes from a large limestone spring. Total hardness of this water averages about 100 ppm.

In recent years quite a number of promising new herbicides have been tested in these hatchery ponds in an attempt to find a more efficient and less costly weed control procedure. During 1960, the herbicide Endothal was tested at application rates of 1.0, 3.0, and 5.0 ppm. in both partial and complete treatments in small ponds ranging from 1/20 to 1/10 acre in surface area. Both the liquid and granular forms of the herbicide were used for comparative purposes.

Pond #1, a narrow raceway-type pond with no inflow or outflow and a surface area of 1/20 acre, received a partial treatment with Endothal liquid on June 16, 1960. The test plot, comprising 20% of the total pond volume and located at the midpoint of the pond, was treated at an application rate of 3.0 ppm. Water temperature within this pond averaged 65°F. One week later *P. crispus*, the dominant plant species in this and most of the other ponds, had begun to decompose and sink below the surface within the test plot and to the one end of the pond in the direction of the prevailing wind. By the end of one month complete control of *P. crispus* was evident in all portions of Pond #1. Periodic checks, continued to the end of September, revealed that no significant control was obtained on water weed, duckweed, or filamentous algae. Regrowth of curly-leaved pondweed was first noted in early August but by the end of September it had not reached the 5% level. Based on total pond volume the application rate required to effect complete control of *P. crispus*, under the conditions prevailing here, would appear to be less than 0.6 ppm.

Ponds #2, 3, 4 & 5 are identical and are arranged side by side in a series. Each one has a surface area of 1/10 acre and during the testing period each one received an inflow of water which averaged 10 gpm. The lower one-third of each pond was treated with either Endothal liquid or granular at rates of 1.0 or 5.0 ppm. All applications were made on June 16, 1960, at which time the water temperature in these ponds ranged between 55°F. and 60°F. At the end of one week *P. crispus* had begun to decompose and recede from the surface in the plots treated at the 5.0 ppm. rate. In the plots treated at 1.0 ppm., *P. crispus* was slightly browned but relatively little decomposition had occurred. Two weeks after the applications were made, *P. crispus* had completely disintegrated within the plots

[1]Endothal, the disodium salt of 3,6-endoxohexahydrophthalic acid, was provided for this study by the Pennsalt Chemicals Corporation.

treated at the 5.0 ppm. rate and control was judged to be 100%. The demarcation between the treated and untreated portions of the ponds was distinct, indicating that the inflow to the ponds had prevented diffusion of the herbicide above the boundaries of the plots.

Decomposition of P. crispus progressed very slowly in the plots treated at 1.0 ppm. By the end of one month some slight regrowth was noted. The maximum control achieved in these plots was 65%. There was no significant difference observed in the effectiveness of the two forms of the herbicide--granular and liquid.

All four ponds in these tests overflowed into a common receiving pond of 1/8 acre surface area. This receiving pond in turn supplied the inflow to a series of four 1/10 acre ponds identical to Ponds #2, 3, 4, and 5. When the Endothal applications were made on June 16 to the numbered test ponds, the receiving ponds below were similarly infested with weed growth. About a month later it was noted that the 1/8 acre receiving pond and also the series of 1/10 acre ponds below had become relatively free of weed growth. Although control was confined only to P. crispus it was not necessary for the hatchery personnel to manually remove vegetation from these ponds for the duration of the summer.

In tests initiated on July 21, 1960, two 1/10 acre ponds received total treatments of Endothal at the rate of 3.0 ppm. Pond #6 was treated with the granular preparation and Pond #7 with the liquid. With the exception of small areas at the intake ends of these ponds, 100% control of P. crispus was realized in three weeks.

By the end of September all treated ponds that received a constant, although small, inflow of water contained regrowth of P. crispus ranging from 5% for those treated at 5.0 ppm. to an average of 40% for those treated at 1.0 ppm. It was calculated that a complete change of water occurred in these ponds in approximately six days.

The very effective control of P. crispus realized in the aforementioned untreated receiving ponds suggested that Endothal might be effective in controlling this plant in trout rearing raceways carrying a substantial flow of water. A raceway approximately one-half mile long located at the Benner Spring Fish Research Station was made available for such a test. This raceway averaged 14 ft. in width. The depth graded from 1.5 ft. at the intake end to 3.0 ft. at the outlet. The flow was reduced to a measured volume of 312 gpm. A section 380 ft. long at the head of the raceway was treated with Endothal granular at 5.0 ppm. At the end of one week close examination of the plants showed that damage to P. crispus was confined to the extreme terminal portion of the stems. This damage was observed from about the midpoint of the treated section to several hundred feet below the treated area. On September 16, about one month after the date of treatment, the raceway was free of P. crispus for a distance of 1300 ft. or roughly one-quarter mile. Partial control extended down an additional 600 ft. Also, only partial control was obtained in a 100 ft. section immediately below the intake. Algae and common water weed, also abundant in the raceway, were apparently not affected by the herbicide.

Although all ponds and raceways used in the Endothal tests contained fish life, no fish kill or indication of distress was observed at any of the application rates tested.

THE ABSORPTION AND METABOLISM OF RADIOENDOTHAL BY FISH AND AQUATIC PLANTS [1,2]

V.H. Freed[3] and Illo Gauditz[4]

ABSTRACT *

Endothal (disodium 3,6-endoxohexahydrophthalate)is a highly active contact weed killer that has found extensive use for pre-emergence weed control in sugar beets, table beets, and spinach. More recently this chemical has been shown to be effective for the control of many aquatic weeds. One of the attractive features of endothal in aquatic weed control is the relatively high tolerance that many species of fish have toward this chemical. This makes it possible to use this chemical for the control of aquatic weeds without serious effect on the fish population.

The use of endothal in aquatic weed control poses the problem as to whether or not the fish would accumulate this chemical. It would be possible for the fish to ingest the chemical directly from the water or if aquatic plants accumulated the chemical, fish may become exposed to the endothal through feeding on the foliage of the aquatic plant. The purpose of the study reported here was to determine whether or not endothal was ingested by the fish from either source and if the endothal were taken up would it pose a problem. Previous work has shown that endothal is extremely unstable under biological conditions so that it was felt unlikely that there would be any serious residue in the fish.

A study of the uptake and distribution of C^{14} from radioendothal in fish and plants exposed to this chemical was undertaken. It was demonstrated that the radioactivity found in goldfish exposed to different concentrations of chemical followed a similar pattern. This pattern revealed extensive breakdown of the endothal molecule and incorporation of its radioactivity into a number of fractions in both fish and plants. The behavior of these different fractions indicates that they are normal constituents of the organism such as carbohydrates, organic acids, amino acids, and proteins, as well as fats and oils. With the analytical technique used, it was demonstrated that the fraction of radioactivity which contains endothal would be the Dowex 1 eluate from the methanol extract. Even at 12 ppm this fraction contained only 0.07 ppm. At the normal range of concentration which the chemical is used, this level is only 0.002 for goldfish. Further study of the elution pattern of this fraction of radioactivity indicates that it is not as endothal. Thus, it may be concluded that due to the extensive breakdown of this chemical and incorporation of radioactivity into normal constitutents of the organism, as represented by the different fractions, that it is doubtful that any endothal remains.

1/* Complete paper to be contributed to WEEDS

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Potential Uses of Calcium Cyanamid in the Control of Aquatic Vegetation

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The manual removal of aquatic weeds from the trout rearing ponds and raceways at the Pennsylvania Fish Commissions' Benner Spring Fish Research Station in Centre County had, prior to the 1960 season, been an operation of considerable magnitude. The dominant aquatic weeds found in these limestone waters include curly-leaved pondweed, Potamogeton crispus; common waterweed, Anacharis canadensis; horned pondweed, Zannichellia palustris; duckweed, Lemna minor; water cress, Nasturtium officinale; and several unidentified forms of filamentous algae. At intervals averaging about once every six weeks during the main growing season it had been necessary to cut and remove this growth from all earth-bottomed ponds and raceways. Scythes and pitchforks were the usual implements employed. Substantial losses of fingerling trout frequently accompanied these manual operations.

In mid-June, 1960, a number of ponds and raceways at this station were drained, scraped to remove accumulated muck and food wastes, and treated chemically with the primary objective of controlling certain fish-disease organisms. Mr. Gordon Trembley, Chief Aquatic Biologist and Mr. Arthur Bradford, Fish Pathologist jointly prescribed and directed the sterilization procedures. Calcium cyanamid, a readily available and commonly used nitrogen fertilizer, was the sterilant used in roughly seventy-five percent of the treated ponds and raceways. This gray, finely-granular material was broadcast uniformly to the exposed bottoms at a rate approximating 100 pounds per 1000 square feet. Schaeperclaus (1933), the German fishery scientist, has written regarding the use of this product for fertilization and disease control in the European pond industry. Calcium hypochlorite and chlorine were the sterilants used in the remaining rearing facilities involved. By July 1, most ponds had been flushed and refilled with water preliminary to restocking with fish. The elapsed time between application of the sterilants and resumption of normal fish rearing operations in the various facilities ranged from a minimum of two days to a maximum of two weeks. In no case did the introduced trout appear to be adversely affected by any residual activity of the sterilants used.

By late August it became apparent to some of the hatchery personnel that the cyanamid treated facilities had remained amazingly free of weed growth as opposed to those treated with the other chemical products. Manual removal of weed growth had to be resumed in the raceways treated with calcium hypochlorite and chlorine by early September. Observations up to the end of October revealed that the calcium cyanamid treated areas were, with only one minor exception completely weed free.

This unanticipated success in controlling or retarding aquatic weeds through the application of cyanamid to exposed bottoms prompted the initiation of several supporting experiments. To explore the potential of this material in controlling weeds in ponds or lakes containing fish populations, a small one-twentieth acre pond at the Benner Spring Station was used. This pond averaged three feet in depth, had no inflow or outflow, was well populated with fathead minnows, and contained the normal array of aquatic plants common to this locality. Calcium cyanamid was applied by broadcasting to the pond surface at the rate of 50 pounds per 1000 square feet. At the end of one week only one living fathead could be found. Dead minnows, polliwogs, and aquatic insects littered the pond bottom. By the end of one month approximately 90% control had been achieved on the plant species present; including duckweed, Lemna minor. Filamentous algae, however, was beginning to show signs of recovery. Reintroduction of fathead minnows at this time showed that the water was no longer toxic to this species.

A second experiment was conducted in a raceway which averaged 16 feet in width and carried a flow of 2.5 cubic feet per second. Here, we hoped to determine if calcium cyanamid would be effective in controlling weeds in flowing water. Calcium cyanamid was applied to a section of this raceway, 125 feet in length, at a rate of 100 pounds per 1000 square feet. Periodic checks of the test area during the succeeding two months revealed that no appreciable control of any of the weed species present had been achieved. The effects of this type of application on fish life was not evaluated since the test raceway had contained no fish.

In summary, observations made during 1960 indicate that applications of calcium cyanamid at the rate of 100 pounds per 1000 square feet to exposed raceway and pond bottoms may be a highly effective and relatively economical means of controlling a wide assortment of aquatic weeds at fish rearing stations. Because of its apparent toxicity to fish life and other aquatic fauna in standing-water applications, calcium cyanamid does not now appear promising as a weedicide for general aquatic use. Testing of this material at the Benner Spring Fish Research Station during 1961 will be concentrated primarily toward determining (1) the minimum effective application rate, (2) the duration of control at the 100 pounds per 1000 square feet rate, (3) the relationship between application rate and duration of control, and (4) the feasibility of partial or marginal applications in ponds containing fish populations with and without partial draw-down.

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SUMMARY OF 1960 AQUATHOL TEST RESULTS

C. L. Bolster[1]

In discussing 1960 aquatic weed control results, we have elected to summarize these as results of "Aquathol" applications rather than the generic usage of "Endothal", 3,6-endoxohexahydrophthalic acid, as our Endothal Aquatic Weed Killer formulations are trademarked "Aquathol" and any further sample distribution will be on this basis.

Federal label approval was received for both the 19.2% liquid and 5% granular Endothal Aquatic Weed Killer formulations in July of 1960; however, this label was based primarily on results obtained in testing prior to 1960.

Our aim in an extensive "Aquathol" test program this past season was to confirm our previous four-year test results on as broad a geographic and weed spectrum control basis as possible.

1960 Results

Over 200 individual weed plot tests were conducted in Northeastern United States and Southern Canada in 1960. Both granular and liquid forms were used and data were obtained on various weed species in large areas on complete pond treatment and with marginal applications in larger bodies of water. Observations were made on the effect on the performance of "Aquathol" of such factors as density of weed growth, water temperature, pH, hardness, turbidity, movement, etc.

A cooperator's manual was provided each cooperator for the purpose of attempting to standardize testing and reporting procedures. The conditions surrounding the field of aquatic weed control present such an assortment of variables beyond those found in the terrestial field, that it was our hope to assist cooperators in reporting their results in such a manner as to provide a common denominator in evaluation.

The following chart, expressed in parts per million concentration, reflects the economic control range for both "Aquathol" formulations, except where noted for the liquid in controlling the Duckweed family.

[1]Pennsalt Chemicals Corporation
Agricultural Chemicals Division

WEEDS CONTROLLED AND AQUATHOL DOSAGE RATE CHART

Common Name	Latin Name	Entire Pond Or Large Area Treatment	Spot Or Lake Margin Treatment
Horned Pondweed	Zannichellia spp.	1-2 ppm	2-3 ppm
Coontail	Ceratophyllum spp.	1-2 ppm	2-3 ppm
Water Stargrass	Heteranthea spp.	2-3 ppm	3-4 ppm
Milfoil	Myriophyllum spp.	2-3 ppm	3-4 ppm
Bushy Pondweed	Naias spp.	.5-1.5 ppm	2-3 ppm
	Potamogeton americanus	2-3 ppm	3-4 ppm
Bassweed	Potamogeton amplifolius	2-3 ppm	3-4 ppm
Curly Leaf Pondweed	Potamogeton crispus	.5-1.5 ppm	2-3 ppm
	Potamogeton diversifolius	1-2 ppm	2-3 ppm
	Potamogeton filiformis	2-3 ppm	3-4 ppm
Floating-Leaf Pondweed	Potamogeton natans	1-2 ppm	2-3 ppm
	Potamogeton pusillus	1-2 ppm	2-3 ppm
Sago Pondweed	Potamogeton pectinatus	1-2 ppm	2-3 ppm
Flat-Stem Pondweed	Potamogeton zosteriformis	2-3 ppm	3-4 ppm
Burr Weed	Sparganium spp.	3-4 ppm	4-5 ppm
Duckweed	Wolffia, Spirodela, Lemna, spp.	Surface contact spray at the rate of 5 gallons liquid "Aquathol" per acre	

Discussion of Results

In consideration of tests in 1960, the following points should be weighed in evaluation of "Aquathol" as an aquatic herbicide:

1. "Aquathol" is a contact action herbicide and it has proven necessary to apply sufficient "Aquathol" to the area treated to maintain a given strength of active ingredient in the water surrounding the exposed tissue surface area of the plant.

2. Aquatic plants appear easier to kill in their more vigorous, earlier growing stage than in late summer after maturity, so it appears necessary to treat after a growth has developed in spring or early summer; after water temperatures have reached a consistent 62-65°F.; and before seeding, where seeding is the normal method of reproduction. "Aquathol" does not appear adaptable for the control of weeds in extremely cold waters.

3. The active ingredient in "Aquathol" formulations is water soluble and diffuses readily and rapidly in water; therefore, it is necessary to use a rate appropriate to the nature of the area treated. Spot treatments and marginal treatments of large bodies of water require higher rates. "Aquathol" does not appear adaptable to bodies of water where there is a great deal of water movement.

4. The results obtained in comparing granular and liquid "Aquathol" formulations point out two areas of specific selectivity of formulation: the granular form appears to slow the diffusion rate of the active ingredient and thus appears the logical choice in spot treatments and where opportunity for diffusion is greater; the liquid form appears specifically more effective in controlling the floating problems such as the Duckweed family and floating algae mats, where contact action is more or less confined to the surface area.

5. In northern areas, Pithophora, Cladophora, and Spirogyra algae appear susceptible to "Aquathol" at the 2-5 ppm rate. However, due to the short residual life of "Aquathol", treated areas which have all the conditions favorable for algae development, may be subject to regrowth within the season. Several aquatic nuisance problems, specifically Elodea and Chara (algae), appear resistant to "Aquathol" in the economic treatment range of 1-5 ppm.

Summary

"Aquathol" is a contact killer effective against a wide number of species of submerged aquatic weeds in the range of 0.5 to 5 ppm. The liquid diffuses more readily than the granular and, therefore, this suggests the use of liquid "Aquathol" for treating large areas and the granular for smaller areas. "Aquathol" formulations (granular and liquid) are now available commercially for aquatic weed control.

PROGRESS REPORT ON CONTROL OF EURASIAN WATERMILFOIL IN CHESAPEAKE BAY

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INTRODUCTION

Eurasian watermilfoil (Myriophyllum spicatum) is widely distributed in Europe and Asia and now is spreading rapidly in this country. Present in New Jersey since the turn of the century, and in the Potomac River (Maryland and Virginia) since 1933, it has been reported recently in the upper part of Chesapeake Bay and in North Carolina, New York, and Tennessee.

Eurasian watermilfoil is closely related to the native watermilfoil, Myriophyllum exalbescens, found mainly in glaciated areas. It is very versatile, growing in both fresh and brackish waters. Beaven (1960) reported that it thrives in waters which are fresh or have a salinity up to 10 parts per thousand but grows much more slowly at a salinity of 15 parts per thousand. Since it is absent in more acid waters, it appears that the alkalinity of brackish water favors growth in tidal areas. This plant readily withstands 3-foot tides and is found in water up to 9 feet deep.

The manner in which Eurasian watermilfoil completely dominates most areas in which it grows has resulted in a severe weed problem. In many embayments of the Potomac River and elsewhere on Chesapeake Bay, it often completely replaces native submergent vegetation including valuable duckfood plants such as widgeongrass (Ruppia maritima), sago pondweed (Potamogeton pectinatus), redhead grass or claspingleaf pondweed (Potamogeton perfoliatus), and wildcelery (Vallisneria americana). The native vegetation, however, can withstand more wind and wave action. A dense but loosely woven blanket of watermilfoil often extends from the bottom to the surface, restricting water movement. This impedes the flow of food to oysters and reduces the oxygen supply under the blanket, which may cause oyster mortality at times. Harvest of oysters, clams, crabs and fish is hampered severely by extensive growths of Eurasian watermilfoil. In addition, dense stands curtail recreational activities (such as boating and water skiing) and lower shoreline real estate values. In dense mats, conditions for mosquito breeding may occur (Springer 1959).

Considerable work already has been done on the control of various species of watermilfoil in ponds and lakes by Younger (1959), Boschetti (1959), Hall (1960), Huckins (1960), and Cortell (1960). Since these studies indicated that both silvex and 2,4-D can kill these plants in inland areas, our main objective was to determine how to apply these procedures effectively in tidal situations so that they would provide satisfactory control of Eurasian watermilfoil without being detrimental to native waterfowl food plants or commercial and sport fishery interests.

Studies on control of this plant have been a cooperative effort. Personnel of the Patuxent Wildlife Research Center furnished pertinent data on identification, distribution, and ecology of Eurasian watermilfoil. Gerald H. Townsend, student assistant at Patuxent, and Richard N. Smith, formerly with the Maryland Game and Inland Fish Commission, participated actively in applying and evaluating treatments, making surveys, and tabulating data. Charles F. Noble and Houston C. Phillips of the Pea Island National Wildlife Refuge in North Carolina assisted in control tests conducted in that area. Francis Beaven of the Maryland Department of Research and Education and Dexter S. Haven of the Virginia Fisheries Laboratory participated in field studies and conducted preliminary investigations on the toxicological effects of control procedures on fish, crabs, and oysters. Edgar H. Hollis of the Maryland Department of Tidewater Fisheries and Royston Medford of the Bureau of Commercial Fisheries supplied information on distribution of the plant in Maryland. Chemical companies, including Allied Chemical Corporation; Amchem Products, Incorporated; Chipman Chemical Company, Incorporated; Diamond Alkali Company; Dow Chemical Company; Pennsalt Chemicals Corporation; and Reasor-Hill Corporation furnished materials and technical assistance.

STUDY PROCEDURE

Studies were conducted in Dundee and Saltpeter Creeks and on the Susquehanna Flats in the upper part of Chesapeake Bay and on Lower Machodoc, Nanjemoy and Piccowaxen Creeks off the Potomac River. Tidal fluctuation in these areas varied from 2 - 2 1/2 feet. Other tests were made in a freshwater impoundment at the Pea Island Refuge.

Most of the tests consisted in the application of granules of attaclay impregnated with herbicide because liquid carried materials are more apt to be transported away by the tide. Also, unpublished work has shown that certain liquid carriers sometimes are harmful to aquatic animal life. Not only can they increase the toxicity of the compound, but they can cause an unpleasant flavor, as in oysters subjected to oil at concentrations as low as 1 gallon to an acre.

Herbicides used for these studies were:

COMMON NAME	CHEMICAL	HOW APPLIED
2,4-D	butoxyethanol ester of 2,4-dichlorophenoxy-acetic acid	granular and liquid
"	dimethylamine salt of " "	liquid
"	iso-octyl ester of " "	granular
"	propylene glycol to butyl ether esters of 2,4-dichlorophenoxyacetic acid	granular and liquid
"	2,4-dichlorophenoxy-acetamide	liquid
Silvex	butoxyethanol ester of 2-(2,4,5-trichloro-phenoxy) propionic acid	granular and liquid
"	propylene glycol to butyl ether esters of 2-(2,4,5-trichlorophenoxy) propionic acid	liquid
MCPA	dimethylamine salt of 2-methyl-4-chloro-phenoxyacetic acid	liquid
4-(2,4-DB)	dimethylamine salt of 4-(2,4-dichlorophenoxy) butyric acid	liquid
Amitrole	3 amino-1,2,4-triazole	liquid
Amitrole-T	3 amino-1,2,4-triazole-ammonium thiocyanate	liquid
Endothal	disodium salt of 3,6-endoxohexahydropthalic acid	granular and liquid
Fenac	2,3,6-trichlorophenylacetic acid	granular
"	sodium salt of 2,3,6-trichlorophenylacetic acid	liquid
FenuronTCA	3 phenyl-1,1-dimethylurea trichloroacetate	granular
Simazine	4-chloro-4,6-bis (ethylamino)-s-triazine	liquid

Plot studies were conducted from late July into August in 1959 and from April into July in 1960. Approximately 170 treatments were made. In initial stages, 1/100-acre plots were used; later, the plot sizes were increased up to 1/5 acre for herbicidal studies and from 1/2 to 1 acre for the studies of the toxicological effect of herbicides on animal life. On the small and intermediate size plots, granular treatments were broadcast by hand from a boat propelled by oars and pushpole. On most of the larger plots these applications were made with a hand-cranked cyclone type seeder from a boat being propelled by a 5-horse power air-thrust motor. In similar manner, spray treatments were applied with hand pressure and power-spray equipment on small and large plots, respectively. Treatments were made at various stages of tide and of plant growth and at various temperatures.

RESULTS

These studies indicated that phenoxy herbicides can control Eurasian watermilfoil in specific situations. 2,4-D granules applied at 20 to 40 pounds acid equivalent per acre gave best results but good control was obtained with granular silvex, a more expensive material, at the same dosages.

Eurasian watermilfoil was most vulnerable to herbicidal treatment when it reached the water surface at low tide and before it began to flower. For satisfactory control with 2,4-D the temperature of the water had to be above 20° C. (68° F.). With the slower-acting silvex formulations a minimum temperature of 22° C. (72° F.) was needed. In order to obtain maximum containment of herbicide by vegetative friction it was necessary to apply treatment during ebb tide near the period of low water slack.

In the Chesapeake Bay and its tributaries the best time for treatment occurred in the latter half of May. Applications of 2,4-D and silvex granules at later stages of growth were not very effective. Spray treatments of the ester formulation of silvex, however, yielded effective results for at least 2 to 3 weeks later. Other chemicals showing herbicidal action were MCPA and 2,4-D acetamide. Compounds that were not effective in these preliminary studies were amitrole, amitrole-T, endothal, simazine, 4-(2,4-DB), fenac and fenuronTCA.

Preliminary pen tests with oysters and crabs by Beaven and Haven indicated that an application of 40 pounds of 2,4-D acetamide per acre was harmful to crabs and oysters, although preliminary laboratory experiments show that this chemical is of low toxicity to oysters.

FUTURE STUDIES

In the future, emphasis will be given to detailed tests with granular formulations of 2,4-D applied on a replicated, randomized basis in fresh and brackish estuarine situations. Other herbicides showing promise will be tested further, and techniques for treatment of the plant under varied conditions will be refined. In order to determine the toxicological hazards of herbicides to fish and wildlife, a series of 1-acre applications will be made in 1961 in cooperation with the Maryland Department of Research and Education and the Virginia Fisheries Laboratory.

SUMMARY

Invasion of Eurasian watermilfoil in fresh and brackish waters from New York to North Carolina and Tennessee constitutes a severe weed problem affecting diversified interests including boating, sport and commercial fishing, and waterfowl hunting.

Preliminary studies on herbicidal control of this problem plant indicate that 2,4-D granules applied at the rate of 20 to 40 pounds acid equivalent per acre give effective results in tidal areas. Time for treatment should be (a) when the plant reaches the water surface at low tide and before it flowers, (b) when the water temperature is above 20° C., and (c) when the tide is ebbing and near the period of low water slack.

Future studies will be directed toward refinement of control techniques and evaluation of the toxicological effects of herbicides on fishery resources.

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