WEED MEN FOR THE FUTURE

By Roy L. Lovvorn 1/

Although man has long engaged in the war against weeds, it was less than 10 years ago that the elimination of undesirable plants by the application of the growth regulators was discovered. Within this short period the entire field has mushroomed almost beyond the imagination of the most fantastic dreamer.

Most of you are now working in one of the most popular fields of science and whether you are aware of it or not, are actually making agricultural history. I would like to discuss with you briefly the scope of present day weed research, to list a few significant accomplishments, and give you my concept of the necessary qualifications needed to solve the problems ahead.

Scope of Activity

According to the Tariff Commission of the United States Department of Commerce, 28,000,000 pounds of 2,4-D were produced in the United States in 1949. This is three times the production of the same herbicide in 1947. Thus 2,4-D is by far the most widely used single herbicide in this country at the present time. Other chemicals are now being more widely used for weed control. L. M. Stahler estimates that 25,000,000 acres in the North Central States and the Cereal Belt of Canada were sprayed with 2,4-D in 1949 and that most of this spraying was done on field crops. My guess is that fewer crop acres but more non-cultivated acres were sprayed in 1950, so that in all probability the total use was somewhere near the same as in the previous year.

Most of you are familiar with the use of herbicides in the control of weeds in the cereals and corn. You know what 2,4-D means in terms of less labor, higher yields, and cleaner grain, but weeds are a far bigger problem in this country than merely controlling them in grain crops.

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Weeds in vegetable crops, likewise, are receiving their share of attention with new developments in that field also. The discovery that 2,4,5-T kills many hardwood species not controlled by 2,4-D has revolutionized the practice of destroying brush on rangeland, and along highways, railroads, power lines, telephone lines, ditchbanks, and canal ditches. One commercial organization alone used approximately 600 tons of ammonium sulfamate for controlling brush last year. The use of 2,4-D in the control of sand sagebrush (Artemisia filifolia) is now an old story, but equally promising results are now being secured with 2,4,5-T on mesquite (Prosopis juliflora), a thorny shrub or tree common on many of the ranges of the Southwest. Nearly 100 million acres of rangeland in the Southern Great Plains and Southwest are heavily infested with mesquite, cedar (Juniperus sp.), sand sagebrush, shinnery oak (Quercus havardi), cactus (Opuntia sp.), and other brushy species. These are spreading in Oklahoma and Texas at a rate of one half million acres annually. According to Fisher, McIlvain and Daniels, the surface has not been scratched in brush control.

For several years now, four Regional Weed Conferences in the United States have held Annual Meetings. Last winter 180 papers were presented at these Conferences. In addition, one Conference publishes a separate report of their Research Committee in which most of the current work is summarized. The most recent report contained 263 papers. Some criticism has been directed at the material presented at these Conferences because it indicates that a great amount of empirical work is now underway. There is some justification for the criticism. The demand for immediate practical information has been so great, however, that the workers in many instances had no alternative. These Regional Weed Conferences are now in the process of establishing a national organization designed to serve the needs of all weed men.

Interest in weed control also reaches into the field of public health through the effects of such plants as poison ivy and various ragweed species. Last year five papers were presented in the section on weeds in relation to public health at your Fourth Annual Northeastern Weed Control Conference.

Aquatic weeds, including both submerged and emerged types, constitute serious problems in many areas. My office has many inquiries regarding the control of such weeds, and probably less is known about their control than any other group. Water weeds include weeds in farm ponds, lake shores, beaches, and water-hyacinth in navigable canals, rivers and bays, and aquatics in irrigation laterals and ditches. You can see, therefore, that not only the farmer but the reclamation engineer, the fish and wildlife man, and the U. S. Corps of Engineers are all struggling with lowly water weeds.

According to L. S. Evans of the Agricultural Research Administration, U. S. Department of Agriculture, every State Experiment Station, with two exceptions, now has at least one active weed research project. Most of the weed projects of the United States Department of Agriculture are conducted cooperatively with State Experiment Stations.

In addition to the research being conducted by State and Federal agencies, many industrial firms in the herbicide field have capable scientists who are conducting extensive weed researches. They not only have made significant direct contributions but have been of real assistance in developing and formulating new materials and providing them for other research agencies.

Significant Accomplishments

Applications of 2,4-D for selective weed control in corn were made during the season of 1947, after a minimum of research work, supplemented with observations. In 1948 it was estimated that more than one million acres of corn were sprayed in Iowa alone. Many of the other Corn Belt States sprayed over 100,000 acres.

The research and practical accomplishments in the development of sound chemical weed control practices in wheat, oats, barley, rice, flax, and sorghums have been truly as remarkable as those in corn. There is no very accurate figure on the number of acres of these crops that were sprayed for weed control in the United States in 1950. However, 25 to 30 million acres would be a conservative guess. Research studies of the life cycle responses of grain crops to 2,4-D as measured by yield, chemical composition, germination, and milling and baking quality have furnished the background for the extensive practical application of 2,4-D for a sound weed control program in these crops.

Intensive investigations on the application of chemicals for weed control in horticultural, ornamental, and vegetable crops have resulted in their use in sweet corn, peas, carrots, dill, parsnips, asparagus, potatoes, lima beans, snap beans, and onions. The development of chemical methods of weed control in plantings of apples, other tree fruits, and strawberries have resulted in considerable savings in cultivation and harvesting.

Chemicals can now be used to supplement sound management and fertilization practices as aids in controlling weeds in pastures and haylands. Such weeds as curled dock (Rumex crispus) and wild garlic (Allium vineale), once established in Ladino clover-grass pastures, are difficult if not impossible to control by cultural practices. These perennials, as well as most broad-leaved annuals, may now be controlled economically and safely by the use of 2,4-D. The development of herbicides that are non-toxic to animals has been significant. The dinitro compounds show considerable promise for killing weeds in new alfalfa seedings as well as in established stands of dormant alfalfa.

With the tremendous advertising of crabgrass killers in 1950, the public has become keenly aware, perhaps unnecessarily so, of crabgrass in lawns. My opinion is that although progress has been made we still must make further trials before we can be satisfied with the use of herbicides in the control of crabgrass in lawns. Fortunately, many broad-leaved weeds in lawns are easy to kill with 2,4-D.

Woody plants along drainage ditches, canals, rights of way, and fence rows, constitute one of the most serious weed problems confronting the farmer of the Atlantic Seaboard. Single applications of 1 pound of 2,4,5-T per acre have resulted in 75 to 90 percent control of 90 to 95 percent of the mixed hardwood species occurring in such areas.

Mesquite in Texas is now being controlled with less than 1 pound of the ester of 2,4,5-T applied as an aerial spray at a total cost of little more than $3.00 per acre. It is estimated that one million acres of mesquite infested rangeland will be sprayed in 1951.

Probably one of the most significant developments in the field of weed control has been the discovery and exploitation of the principle of low-gallonage spraying. Not only has weed control research resulted in the development of a very practical and economical method of applying herbicides, but it has also emphasized the possibility of applying insecticides and fungicides by the same method.

The Problem Ahead

Your achievements have been great, but you cannot rest on your laurels or any other part of your anatomy. Your region in particular needs more information on the control of weeds in horticultural and forage crops and in lakes and ponds. Other regions too have acute problems. Some of the current ones are Halogeton (Halogeton glomeratus) on ranges in the far West, salt cedar (Tamarix gallica) in the river bottoms of the Southwest, and giant foxtail in the Corn Belt. More significant perhaps than any of these practical problems is the need for more studies on the physiological mechanisms involved in the killing effects of herbicides. The use of radioisotopes in this connection is already opening new approaches that were hitherto impossible. But as we learn more we also learn of more things that we do not know.

Much of the weed research in the past has been done by many of us who were trained for other duties, but have been transferred into weed work because of an insufficient supply of adequately trained men. The intensity of this problem has lessened. Future weed research will be done by men trained specifically for the job.

If empirical testing is to be replaced by fundamental studies, the men must first be trained in fundamental sciences. Men working in the applied phases must have an understanding of biochemistry, organic chemistry, plant physiology, morphology, ecology, taxonomy, and soil science. Obviously no one person is capable of excelling in all of these sciences. Much of the work must, therefore, be done by chemists, plant physiologists, plant morphologists, ecologist, horticulturist, and agronomists. Just as those working in the applied phases must have an understanding of the supporting sciences, so must the laboratory personnel be equally appreciative of the field problems and of the relation of their particular segment to the entire picture. Teamwork between the field and laboratory workers, therefore, is essential.

Equally as important is the necessity for teamwork between the weed researchers and others in related agricultural sciences. To be most efficient in killing weeds in carrots one must first be familiar with the art and science of carrot culture. Thus the weed man must fit himself into the pattern whether it be with horticultural crops, field crops, grasslands or in the field of forestry.

The agricultural engineer must also be closely associated with the plant scientist because his capacity to develop the necessary mechanical equipment is almost directly proportional to his knowledge of the over-all problem.

In my travels throughout the United States during the past year, I have had an opportunity to see many weed research programs, particularly those at the State Experiment Stations. At some institutions work is being conducted in the Departments of Agronomy, Horticulture, Botany or Agricultural Engineering, and a question frequently asked is, "Where should the research work be done?" My opinion is that the work should be centered where there exists qualified men willing to tackle the job cooperatively. There is no place for isolationism in weed research.

My statements regarding cooperative research are equally appropriate in the dissemination of this knowledge to the public. All of us have constituents regardless of whether they be a board of directors or the tax paying public. There is a great need for centralizing the source of recommendations as well as pooling the experimental results.

All of us think we are awfully busy. It seems to be the fad to jump from one duty to another with the speed and fineese of a deer. The superficial glamour has worn off of weed research and perhaps we need a little more armchair research or to dig the hole a little deeper. Thinking is hard work even if one has the necessary equipment.

I appreciate the opportunity of appearing on your program.

Absorption of Some New Herbicides by Plants

Paul J. Linder[1]

Since the introduction of 2,4-D as an herbicide, many chemicals both old and new have been brought to public notice because of their herbicidal properties. For the most part, attention has been focused mainly on some of the newer organic compounds which show promise of being selective in their killing effect. Some of these newer compounds which were used in the present experiments include: sodium 2,4-D ethyl sulfate, the 3,6-endoxohydrophthalate compounds, maleic hydrazide and phenyl mercuric acetate. Among the older or better known ones used were: Isopropyl-N-phenyl carbamate (IPC) and Methoxone. We all realize that none of these herbicides, neither the old nor the new, offer a completely effective means of weed control.

But in order to get the best effects possible with these new herbicides, as well as with the old ones, it is necessary for us to understand how these chemicals get inside of a weed. Are they absorbed most readily through the leaves, the stem, or the roots? Do they move readily upward or downward in the plant? Is there a means where-by we can increase the amount of the chemical absorbed and the rate at which it is moved from one part of the plant to the other and thus do a better job of killing those weeds that are difficult to control?

In attempting to answer some of these questions, it was best to use experimental plants which were sensitive to the chemicals involved and which could be readily grown under greenhouse conditions so that experiments could be continued throughout the year. Snap beans of the Black Valentine variety and Clinton oats were selected to represent a test plant of the broad-leaf variety and of the grass type.

A series of experiments was then undertaken to determine how to apply these herbicides so as to get the greatest amount of killing effect. The compounds were placed either on the leaves, on the stems or on the roots; and their killing effects or the amount that they checked plant growth was recorded. A standardized procedure was used in treating the plants throughout all of the experiments. Treatments of the grass plants were confined to the leaves and roots. In treating leaves and stems, the chemicals were applied to known areas and care was taken to prevent contamination of other parts of the plants. Narrow bands of lanolin were used to prevent the mixtures from spreading outside of the treated areas. The amounts of various herbicides applied in the respective treatments are given in table 1.

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Table 1. Dosage levels of herbicides applied to test plants

Plant part treated	Dosage level in mgs. applied as treatment		
	Low	Medium	High
Leaves and stems	0.005	0.05	0.5
Roots	0.5	5.0	50.0

All above aqueous mixtures contained a wetting agent, Tween-20, at a 0.1% concentration except those applied to oat leaves which contained Tween-20 at 0.5% concentration

Results and Discussion

Sodium 2,4-dichlorophenoxy ethyl sulfate:- When applied to the lower leaves of broad-leaved plants, sodium 2,4-dichlorophenoxy ethyl sulfate[1] was not absorbed and translocated in sufficient amounts to injure other parts of the plants. Applied to the stem, the compound caused slight suppression of top growth at the highest dosage level, but it did not kill any of the plants. In contrast, application to the soil resulted in death of all the plants at the two highest dosage levels used.

Application of this herbicide to leaves of oat plants resulted in only slight injury, the extent of which was limited to the treated part of the leaves. When applied to the soil, however, all of the oat plants were killed at the highest dosage level.

These experiments indicate that to obtain greatest kill this compound might best be applied to the soil so as to be taken up by the roots.

3,6-Endoxohydrophthalates:- The 3,6-endoxohydrophthalates[2] have been found by others to constitute a group of compounds that possess herbicidal properties. These include 3,6-endoxotetrahydrophthalic anhydride, 3,6-endoxohexahydrophthalic acid and disodium 3,6-endoxohexahydrophthalate.

No evidence was obtained to indicate that these compounds are translocated in a downward direction by young oat plants or young bean plants in sufficient amounts to bring about serious injury below the treated portion of the plant.

From the standpoint of the entire plant (bean) relatively slight injury occurred when the chemical was applied to the leaves, even when the highest dosage level was used. The extent of injury following leaf treat-

[1]Supplied by Carbide and Carbon Chemicals Corp., New York, New York.
[2]Supplied by Sharples Chemicals Inc., Philadelphia, Pa.

ments was limited to a burning of the treated area and a slight supression of top growth. The highest dosage level did, however, cause many of the treated leaves to absciss, but it did not kill the plants. In contrast, 100% kill occurred when an equal amount of the chemical was placed on the lower part of the stems. This would indicate that the compound was much more injurious to the plant as a whole when applied to the stem than when applied to the leaves.

Using oat plants, application of the salt form to the entire upper surface of individual leaves killed those leaves that were treated, but did not injure the rest of the plant. Apparently the compound was not translocated from the leaves of the grass to other parts in sufficient amounts to cause injury.

Application of the 3,6-endoxohydrophthalate compounds to the soil in which bean and oat were growing resulted in 100% kill of both kinds of plants, indicating that the chemical killed the plants by injuring the roots or that it was absorbed by the roots and translocated upward thus causing an over-all herbicidal effect.

On the basis of the present experiments, the compounds might best be applied to the soil, or in the case of broad leaved plants, to the stem in order to get the greatest amount of kill. The practicability of using any of the 3,6-endoxohydrophthalates on soil to inhibit or prevent growth of plants has not been explored in these experiments.

Maleic hydrazide:- Applied in moderate amounts, maleic hydrazide[1] was absorbed and translocated by leaves of bean in sufficient amounts to check top growth of the plants. At the highest dosage level maleic hydrazide caused the terminal shoot to fall off. The treated leaves, however, remained attached; but the stems broke at the second node. The same effect was obtained when this compound was applied to the stem. Applied to the soil, the highest dosage level caused a retardation in growth of the plant and the tops again dropped off of many (43%) of the plants. Contrasting the action of maleic hydrazide with the 3,6-endoxohydrophthalate compounds, it is of interest that the former caused the tops to fall off while the latter caused abscission of the treated leaves.

Maleic hydrazide caused the over-all size of oat plants to be reduced when the highest dosage level was applied to either the leaf blade or to the soil. Neither bean nor oat plants were, however, killed.

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[1]Supplied by United States Rubber Company, Naugatuck Chemical Division, Naugatuck, Conn.

The results indicate that maleic hydrazide in a water mixture is readily absorbed by the leaves and roots and then translocated in an upward direction within the plant.

In an additional experiment it was found that in water this compound was also translocated downward from a treated leaf. It prevented the growth of all buds located below the treated leaves.

It is concluded that maleic hydrazide water solution was translocated both in an upward and downward direction in the stem when applied to the leaves and it was readily absorbed and translocated to the top of the plant when applied to the roots.

Methoxone:- Methoxone[1] (2-methyl-4-chlorophenoxyacetic acid) when applied to the leaves as the sodium salt or the butyl ester was absorbed and translocated in sufficient amounts to cause curvature of the stems and a retardation of growth, but injury was not sufficient to kill the plants. Applied to the stem the compound cuased severe malformations. It apparently moved downward into the roots and finally killed as many as 50% of the plants when the highest dosage level was used.

Soil application of the salt caused 100% kill at the medium and highest dosage levels.

Using oat plants, the salt killed only about 33% of the plants when the leaf blades were treated with the highest dosage level; however, when applied to the soil 100% were killed.

Upon treating leaves with Methoxone, it became apparent that large doses of an herbicide do not always bring about the best kill. In these experiments with Methoxone the highest dosage on the leaves caused no apparent over-all injury while a moderate dose caused very marked overall injury. With the highest dosage the only injury was a localized burning effect on the leaves. This indicates that absorption and movement of this mixture was limited by the destruction of cells at the point of treatment.

Isopropyl-N-phenyl carbamate:- Isopropyl-N-phenyl carbamate, known more commonly as IPC, was compared with a chlorinated form of IPC[2] for absorption and translocation. Neither of these compounds were absorbed or translocated in the bean plant in a sufficient amount to cause injury when applied either to the leaf or stem. Applied to the soil IPC had no effect

[1] Supplied by Chipman Chemical Company, Inc., Bound Brook, New Jersey.

[2] Supplied by Pittsburgh Plate Glass Company, Columbia Chemical Division, Pittsburgh, Pa.

on bean, but on the other hand the "chloro" IPC retarded growth at both the medium and highest dosage levels.

The oat plant showed no effect due to treatment when either of these compounds were applied to the leaf blade. However, they stunted the growth of oat plants when applied to the soil. There was also a noticable thickening of plant parts at the soil level.

Domestic ryegrass a plant sensitive to IPC, was also used in these tests. These compounds were applied as a soil treatment to pots containing germinating ryegrass seed, with the result that 100% kill was obtained.

Evidently these compounds are not absorbed and translocated in any sufficient quantity to cause injury when applied to the above ground parts of plants used in this experiment. They would appear to have their best herbicidal effects when they are applied to the soil containing germinating seed or young seedlings of susceptible species.

Phenyl mercuric acetate:- Phenyl mercuric acetate was not absorbed and translocated in any great amount when applied as a treatment to the leaf or stem of the bean seedling. These treatments caused a slight to severe burning on treated parts depending upon the concentration used. Leaf treatments at the medium and highest dosage levels resulted in abscission of the treated leaf at the base of the petiole in 100% of the plants. When the medium and highest dosage level treatments were applied to the stem, localized burning of the stem was severe enough to cause death of the plant. Applied to the soil, the highest dosage level was effective in killing about 50% of the plants.

Using the oat plant, the treated leaf blade was burned due to treatment, with the three dosage levels but none of the plants were killed. Soil treatment at the medium and highest dosage levels brought about a retardation in over-all growth. In addition, the highest dosage level applied to the soil resulted in a 50% kill of plants.

In some other greenhouse experiments phenyl mercuric acetate was applied to young crabgrass seedlings, about 1/2 inch high. Some were treated on the leaves only, and others on the roots through applications to the s oil. The leaf treatment caused pronounced localized tip burning without permanent injury to the plant. The soil treatment, on the other hand, resulted in rapid destruction of the stems and roots followed by death of all of the plants in the treated soil. On the basis of these experiments there appears to be a marked difference in degree of sensitivity of oats and crabgrass to phenyl mercuric acetate.

Summary

The results of tests using these six herbicides are summarized as follows:

Sodium 2,4-D ethyl sulfate:- Application to the roots resulted in the best kill.

3,6-endoxohydrophthalates:-	Application to the stem and roots were both relatively effective in kill.
Maleic hydrazide:-	About the same amount of injury was obtained from either, root, stem or leaf application.
IPC and "chloro" IPC:-	Relatively ineffective when applied to leaves and stems of both broadleaved plants and also grasses.
	Soil application most effective especially when applied to germinating seed or young seedlings.
Phenyl mercuric acetate:-	Soil application most effective with application to the leaves of young grass also relatively effective.

Theories on the Herbicidal Action of Petroleum Herbicides

S. L. Dallyn and R. D. Sweet

The selective action of Stoddard Solvent-type oils is well known. At the present time practically all commercially grown carrots are weeded in this manner. The questions of why different plants react so differently to the same oil and why only certain oils can be used satisfactorily in this role are yet to be answered.

The paper presented here is a summary and discussion of the findings from extensive experimentation by the senior author. The complete paper will be published elsewhere.

Review of Published Theories

Although considerable literature is available on the use of petroleum oils as herbicides, only a few authors have attempted to explain the mechanism of plant tolerance or susceptibility as exhibited by carrots or conifers and grasses or legumes respectively.

Crafts (1946) described plant tolerance as a characteristic of the protoplasm of resistant plants but made no mention of the mechanism involved. Accordingly one would expect little variation in plant response to oils even when grown prior to treating over a wide range of environmental conditions. Data presented in this paper tends to support Crafts' theory.

Minshall and Helson (1949) reported the effects of Stoddard Solvent on transpiration, respiration, and photosynthesis of parsnip and mustard. They suggested that parsnip survived the treatments because of internal structural advantages which permitted many cells to remain supplied with water in spite of an interfering action of the oil. Mustard plants, however, succumbed because of a "blocking action" by the oil which prevented a high proportion of the leaf cells from receiving water. They attributed an almost immediate and complete cessation of photosynthesis to a lack of water as a raw product. This interpretation is difficult for these authors to support since it does not satisfactorily explain the wide variation in plant response to chemically different oils of similar physical properties.

Havis (1949) found a high percentage of plants with oil systems showed some resistance to herbicidal oils. He proposed that naturally occurring oils might (1) reduce the quantity of spray oil entering the plant, or (2) act as diluents, thus reducing toxicity of that which did enter, or (3) localize it in specialized tissue of the natural oil conductive system. While Havis (1949) and Minshall and Helson (1949) suggest that at least a partial answer to tolerance and selectivity lies in anatomical and morphological characteristics, which reduce entry or modify and retard movement after entry into the leaf, qualitative evidence obtained by the authors in microscopic examinations indicates that oils penetrate the leaves of both resistant and susceptible plants. It was established also that carrot leaves retain larger quantities of spray oil than do those of bean, a susceptible plant. This tends to negate the suggestions that quantitative differences in penetration might account for selectivity.

To further test the role of essential oils, distillations were made of untreated carrot foliage. The amounts of these materials which were recovered were extremely small and were considered negligible in relation to the quantities recovered from spray applications. This would seem to indicate that natural oils are of little importance in diluting the petroleum oils as suggested by Havis. The herbicidal properties of commercial samples of oil of carrot seed and oil of dill weed were determined. Both carrot seed oil at 20 to 25 percent and dill weed oil at 30 to 35 percent, in a non toxic diluent, gave good selective action. These results further suggest the presence of materials in carrots which are toxic to other plants, and in addition that they probably could not act as diluents since in the "pure" form at least they are considerably more toxic than commercial Stoddard Solvent.

A New Theory on the Mechanism of Plant Tolerance and Susceptibility to Oils.

Fairly early in the present studies it appeared reasonable to postulate that carrots and related plants might be tolerant of certain oils because of some characteristic of their cytoplasmic membranes which restricted entrance of the oil into the cell. A critical examination of the literature coupled with the evidence obtained from extensive anatomical studies by the author permits the conclusion "if cell penetration is accomplished by an oil, that cell is almost certain to be destroyed, or at the very least, severely injured. Thus the term "protoplasmic resistance" as mentioned by Crafts (1946) is not entirely correct.

The fact that Stoddard Solvent-type oils like Varsol #1 spread indiscriminately between and into bean cells yet remain confined to the intercellular spaces of carrots is strong supporting evidence that the cytoplasmic membranes are playing an important role in determining selectivity. When Stoddard Solvent was increased in aromatic content by the addition of an aromatic hydrocarbon in sufficient amounts to bring about injury to carrots, it was noted that the oil was no longer confined to the intercellular spaces but that cell penetration had now occurred. It seems logical to assume for working purposes that the differences between tolerant and susceptible plants, and between toxic and non-toxic oils is one of degree and further, that probably but one mechanism is involved.

Additional supporting evidence for the importance of the cytoplasmic membranes was provided by emulsion experiments. In general, emulsion behavior was expressed by a loss of selectivity, with increased damage to carrots and decreased toxicity to susceptible plants. Essentially this means that the degree of differential response between the two types of plants had been reduced.

Certain of the surface active agents employed in the emulsions were in themselves slightly toxic at the concentrations used. In no case, however, did this toxicity even remotely approach the increased injury suffered by carrots and other tolerant plants from emulsions of normally selective oils. Further evidence that these materials were not responsible, per se, for the increased injury was provided by the fact that an emulsion was never as toxic to beans and similar susceptible plants as an equal amount of the pure oil.

The fact that highly toxic oils could be made selective by dilution with a non toxic oil but not with water seems somewhat contradictory at first. This is especially true when one considers that the so-called non toxic oil actually does have some slightly harmful effects on plants while water has none.

There are several possibilities involved which may relate the general behavior of emulsions to the permeability theory.

(1) Oil in emulsion form exists in very minute globules which theoretically, by reason of increased area of contact, would be better able to penetrate a resistant material.

(2) Oil droplets as the internal phase of the emulsion carry a negative charge. The significance, if any, of this fact is not known at the present time. The magnitude of this change in the electrical condition of the oil is sufficient that its possible importance should not be discarded until more work has been done on it.

(3) In certain industrial processes when an oil mixture is emulsified, there is an accumulation of the aromatic fractions at the periphery of the oil droplets. For example, Varsol #2 has an aromatic content of about 30%. Thus when emulsified the very outer edge of the droplets might be actually 50% aromatic and the rest would average under 30. This high aromatic content at the point of contact with the membrane would be very likely to cause injury either directly to membrane itself or in allowing the rest of the oil to enter unobstructed, thus bringing about the death of the cell involved.

(4) Emulsions generally assume the physical characteristics of the external phase. Thus the typical oil-in-water type readily incorporates into the system any free water that is added to it. The walls and membranes of the cell are bathed in water which might offer some resistance to the entrance of an oil. Such emulsion, however, would be able to pass through this obstacle without opposition by merely emulsifying with it. In this investigation it was found that oil-in-water emulsions caused significantly more damage to carrots than did those of the water-in-oil type. The latter, having the physical properties of an oil system, would not possess the advantage of being able to incorporate plant fluids into the emulsion. The evidence suggests that this factor may be of considerable importance in explaining the action of emulsions.

The increased damage to carrots from oil emulsions can therefore be explained on the basis that the emulsified oil was able to penetrate the normally resistant cell membranes. Susceptible plant cells such as those of beans are readily penetrated by oil in its natural state and emulsifying it, therefore, was a disadvantage since it reduced the amount of toxicant actually placed on the plant.

Attempts to vary the permeability of plant cells to oils were, in general, not very successful. The fact that low temperature-hardened cabbage plants are much more susceptible to oil injury than are those not hardened might appear to be conclusive evidence that a permeability change had occurred, and that this would support the importance of the role of the cytoplasmic membrane in determining selectivity. Another point is involved however which may be worthy of some consideration. Cells of the hardened plants were smaller than those which had received no check in growth. Small cells have a much greater surface-volume ratio than large cells. Thus the amount of oil observed inside the cells might be accounted for partially by the fact that a much larger percentage of the surface of a small cell would be covered by a given quantity of oil than would that of a large cell. In spite of this the author believes the fact that hardened plants are more easily injured is at least suggestive that a permeability factor, as measured by penetration of the cell by the oil, is involved in selectivity.

If permeability is actually the factor involved one is led to conclude from the results of the experiments reported here that the membranes, of tolerant plants at least, are by nature relatively impervious to the entrance of certain petroleum oils and only when injured or in some way modified do they allow it to penetrate. Variation in permeability of the membranes, therefore, would have little or no influence on oil penetration as long as they were still functioning normally.

In contrast to the lack of response in the cell permeability experiments, changes in the chemical nature of the oil applied to the plant would be expected to have a profound effect on plant response. Many workers as well as the data presented in this study show this to be the case. Havis (1949) showed the relative toxicity of thirty-odd pure hydrocarbons to be aromatics, naphthenes, olefins, and straight chain paraffins, in descending order. Havis (1949) also pointed out this order of herbicidal activity agrees with certain chemical properties of the oils such as their solvency for many organic compounds such as gums, resins, dyes, phenolic compounds, etc. It is reasonable to assume that the capacity of the hydrocarbons to react with the cytoplasmic membranes would also be in this same relative order.

The characteristic chemical behavior of the various hydrocarbons coupled with the striking differences between toxic and non-toxic hydrocarbons in regard to their mode of entry, cell penetration, and distribution within plants soon after application further strengthens the hypothesis that plant tolerance and susceptibility are a matter of degree and that differences in the cytoplasmic membranes are the key to the mechanism responsible for selectivity.

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SOME EFFECTS OF CONCENTRATION OF 2,4-D AND pH OF SOLUTION UPON PLANT RESPONSES[1]

Harold E. Clark and Samuel R. Freiberg[2]

INTRODUCTION

The importance of due consideration of the fate of 2,4-D in the soil, and of the effects upon plants of 2,4-D available in the root zone, has been emphasized by the work of a number of investigators (1,5,9,14,16). Experiments at the New Jersey Agricultural Experiment Station on factors affecting absorption of 2,4-D and related compounds have thrown some light on the mechanism of absorption of 2,4-D by roots. The dominant role played by the pH of the culture solution bathing the treated roots has been particularly evident (7). In our attempts to evaluate responses of plants treated with 2,4-D dissolved in nutrient solutions, we have noted several responses which may contribute to an understanding of the mode of action of 2,4-D. Under conditions favorable for the absorption of 2,4-D by roots, it appears that the growth-regulator is quickly translocated to the tops, presumably in the transpiration stream (cf. also 8,12). With plants grown in solution culture, it has been possible to note responses in roots as well as in tops following exposure to 2,4-D dissolved in the nutrient solution.

EXPERIMENTAL METHODS

All plants used in the tests to be described were grown in the greenhouse in continuously aerated solution cultures according to the general techniques of Shive and Robbins (15). Several species of plants have been used, but soybeans will be used to illustrate most points. A standard technique for treatment of the plants with 2,4-D was used, consisting of the exposure of the roots for a period of 24 hours to a desired concentration of sodium 2,4-dichlorophenoxyacetate or 2,4-dichlorophenoxyacetic acid dissolved in fresh minus-N nutrient solution. After the 24-hour exposure period, the roots were rinsed and placed in fresh nutrient solution without 2,4-D and the plants were observed for as long as three weeks.

Several criteria of response were employed, including (1) dry weight of tops and roots, (2) curvature of stems and epinasty of petioles, (3) wilting, yellowing, and drying of leaves, (4) inhibition of stem elongation, (5) proliferation of roots in the stem, (6) root pressure as indicated by bleeding of cut stumps or guttation, and (7) abnormal growth of lateral roots. Several of these criteria have been used by different investigators working with other plants and other methods of application (6,8,9,11,16,17).

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2/ Professor and Research Fellow, Plant Physiology Department, New Jersey Agricultural Experiment Station and Rutgers University, New Brunswick, New Jersey.

OBSERVATIONS AND RESULTS

Effect of pH

Before the various responses are considered, it might be well to bring out the marked effect of the pH of the nutrient solution on response to 2,4-D. Earlier findings (7) need not be reviewed here except to point out that a given concentration of 2,4-D in a pH 4 nutrient solution was far more toxic to plants than the same concentration in a pH 7 solution. It is interesting to note that others (1) have found that the pH of soil to which 2,4-D is added has a similar effect upon the toxicity shown.

It appears that the rate of absorption of 2,4-D by roots is much faster from a nutrient solution at pH 4 than from one at pH 7. On the basis of the reported dissociation constant of 2,4-dichlorophenoxyacetic acid (2), it is suggested that the undissociated acid, a form in which some of the 2,4-D is present in a pH 4 solution, is more rapidly absorbed than is the dissociated anion, the only form present in a solution at pH 7.

Responses from high concentrations of 2,4-D in pH 7 solutions have been very similar to those seen following treatment with much lower concentrations in pH 4 solutions. We are assuming that observed differences in degree of response at the different pH levels reflect differences in the amount of 2,4-D actually absorbed by the plant. With this assumption, an increased range of comparisons can be made with the data now available to us.

Wilting and drying of leaves

Wilting of the topmost expanded leaf of soybeans was noticeable within 3 hours of the start of treatment with a high effective concentration of 2,4-D (10 ppm. at pH 4). Some recovery from this wilting occurred during the first night, but the symptom became more pronounced the following day. No early wilting was observed when lower concentrations were employed. Indeed, low concentrations, up to levels which caused death of the plants within a week or less, often resulted in a lower percentage of dry matter in the leaf tissue than in untreated controls (Table 1). In other words, a certain concentration at first increased the capacity of the tissues to hold water, leaves being crisp, turgid, and apparently healthy. Later these plants died. A higher concentration of 2,4-D, however, produced early wilting, and the leaves lost their capacity to hold water, or perhaps the roots lost their ability to supply water to the tops. Whether the increased water content of the tops was related to cytoplasmic hydration (4), effects on the osmotic concentration of the cells (13), degree of opening of stomata (3), or perhaps to other mechanisms (10) has not been established.

Yellowing of leaves, progressing from the base towards the tip of the stem, was an indication of approaching death of plants given a lethal concentration of 2,4-D. The amount of leaf area remaining green and turgid was used as a measure of the ineffectiveness of treatments (Figure 1). When the highest concentration of 2,4-D (50 ppm.) was used, leaves wilted and dried before losing their green color.

Table 1. Effect of 2,4-D treatment upon percentage of dry matter in soybean leaf blade tissue (Exp. E).

Days after treatment		0	1	4	7
		% D.M.	% D.M.	% D.M.	% D.M.
Low-N plants	Controls	19.8	20.1	20.1	20.8
	Treated*	----	18.6	16.9	24.4#
High-N plants	Controls	16.6	17.0	16.1	17.8
	Treated*	----	15.8	21.0#	68.3#

*Treated plants exposed for 24 hours to 4 p.p.m. 2,4-D in minus-N nutrient solution at pH 3.9.

#Leaves wilting and drying as tissues died.

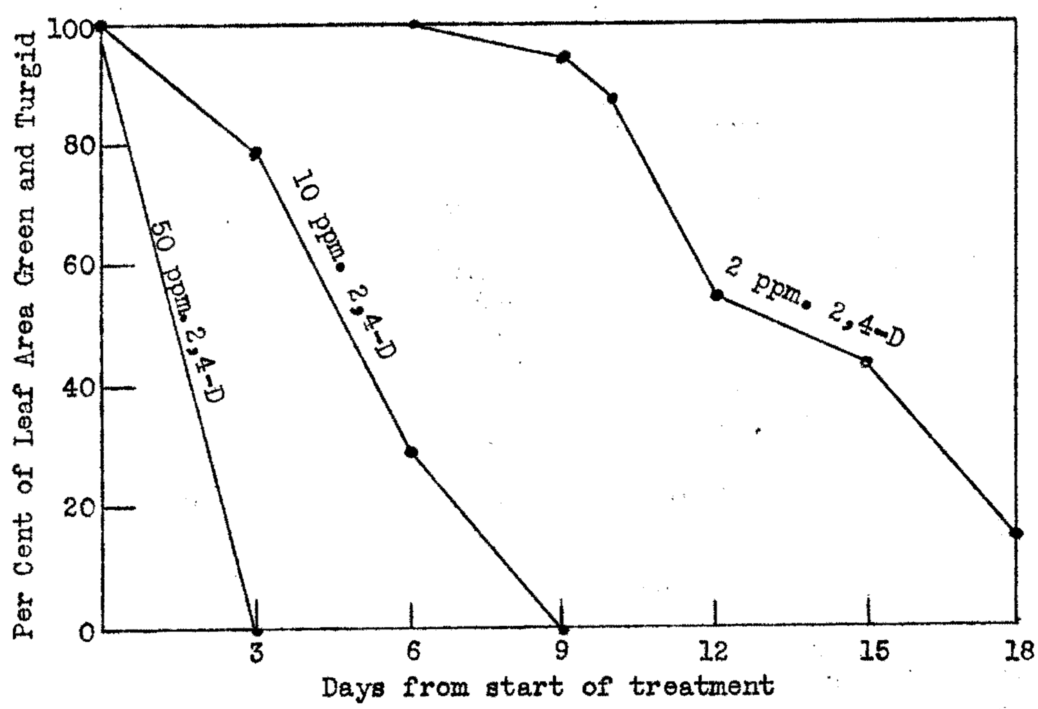

Figure 1. Area of soybean leaves green and turgid following 24-hour exposure to different concentrations of 2,4-D dissolved in pH 4.2 nutrient solution (Exp. G).

Injury to roots

A high concentration of 2,4-D, e.g. 10 ppm. at pH 4, caused early changes in the roots which affected their ability to absorb water, and possibly minerals. When first removed from the treatment solution at the end of 24 hours, roots given this high concentration of 2,4-D had lost their glossiness, and appeared water-soaked. Soybean plants harvested one day after treatment showed no bleeding from the cut stumps when the tops were severed from the roots, in contrast with untreated controls which bled freely. An effect of treatment on root pressure was also seen on corn plants in which those treated with 2,4-D at pH 4 showed no guttation 12 hours after the start of exposure to 2,4-D when the controls were guttating copiously under humid conditions in the early evening.

Changes in pH in the nutrient solutions in which plants were growing following treatment with 2,4-D indicate that the absorption of ions was affected by treatment. Even during a 24-hour exposure to 10 ppm. 2,4-D in a minus-N solution the pH increased from 4.0 at the start of the period to over 5.0 at the end. During the same interval controls increased the pH only from 4.0 to 4.45 at the most. After treatment all plants were placed in fresh minus-N nutrient solution at pH 4.7 without any 2,4-D present. Four days later the plants previously treated with 2,4-D had increased the pH of the solution to 5.7, whereas the controls had decreased the pH to 3.7. No analyses have yet been made, but the shift in pH presumably reflects some effect of treatment on the relative absorption and excretion of cations and anions.

Curving of stem tips and epinasty

High effective concentrations caused this response within 3 to 5 hours of the start of exposure. The stems bent over in the internode between the topmost fully expanded trifoliate leaf and the next higher leaf on the stem, moving through a maximum of about 160 degrees. No concentration was employed which exceeded the level required to produce this response. Lower concentrations were not effective. Delayed curvature of stem tips has been observed following treatment of soybeans with other compounds having growth-regulating properties similar to 2,4-D, but not with low concentrations of 2,4-D itself.

Loss of chlorophyll from stems associated with proliferation of roots in the stems

This change, showing as a whitening of the surface of the stem from the base to a distance towards the tip dependent upon the concentration of 2,4-D used, was associated with a loosening of the cortical tissue following proliferation of many roots within the stem. A lighter color on affected stems became distinct by the third day after treatment, and the portion of stem affected at that time changed little later. Caused by a fairly high effective concentration of 2,4-D, e.g. 2 ppm. at pH 4, the symptom was not produced at low concentrations, and also did not develop at very high concentrations (Table 2). It appears that death of stem and root followed so quickly after exposure to the highest concentrations of 2,4-D that no further growth of tissues including such proliferation of roots in the stem, was possible.

Inhibition of stem elongation

This response was readily measured in soybeans submitted to treatment. The degree of inhibition of elongation of the stems was related to the effective concentration of 2,4-D in the nutrient medium (Figure 2). The highest concentrations of 2,4-D used caused complete inhibition. The lowest concentrations employed caused slight but definite limitation in growth, which was, indeed, the only response visible in the tops within two weeks after treatment. The significance of this restriction in elongation of the stems is not yet fully apparent. It may represent an indirect effect of changes in roots which might limit absorption of minerals and of water, or it may be related to localized effects of 2,4-D upon cell division or cell elongation at the tips of the stems.

Stimulative effects in the roots

Although high concentrations caused early death of soybean roots, very low effective concentrations, i.e. those at pH 7 caused a type of fasciation of lower laterals, and the stimulation of upper laterals. These changes were not recorded in any quantitative manner, but were clearly observable, and definitely related to the effective concentration of 2,4-D in the nutrient solution. Here again, a minimum low concentration was necessary for stimulation, but a higher concentration presumably killed the roots before such changes could occur. Similar results were shown by corn.

Sequence and correlation of responses

Not all responses in the plants, which were observed when a high concentration of 2,4-D was used, became visible at the same time. Examples of early reaction were wilting of the youngest leaves, curving of the stem tips, and change in the roots indicating loss of capacity to absorb water. Other responses were not evident for several days, such as the loss of green color in the stems of plants associated with the proliferation of roots in the stem, and the swelling of lateral root tips. Perhaps these later responses really were initiated at the same time as those seen earlier, but growth of new tissues was involved which take some time for development to a stage visible externally.

Different concentrations of 2,4-D were required to produce different responses. For this reason, all of the changes mentioned above were not seen in any one treated culture. For those responses which involved new growth, such as the proliferation of roots in the stem, and the stimulation of enlarged laterals in the roots, a certain minimum concentration was required for each response, and beyond a certain maximum concentration, there was no stimulation at all. Responses in the water economy of the

Table 2. Effect of concentration of 2,4-D upon visible swelling and whitening of soybean stems 6 days after treatment* (Exp. G).

2,4-D conc. (p.p.m.)		50	10	2	0
Stem height before treatment (cm.)		48	48	46	45
Length of stem with visible whitening and swelling	cm.	0#	42	20	0
	% of total length	0	88	43	0

*Treated plants exposed for 24 hours to 2,4-D in minus-N nutrient solution at pH 4.2.

#Plants dead within 3 days

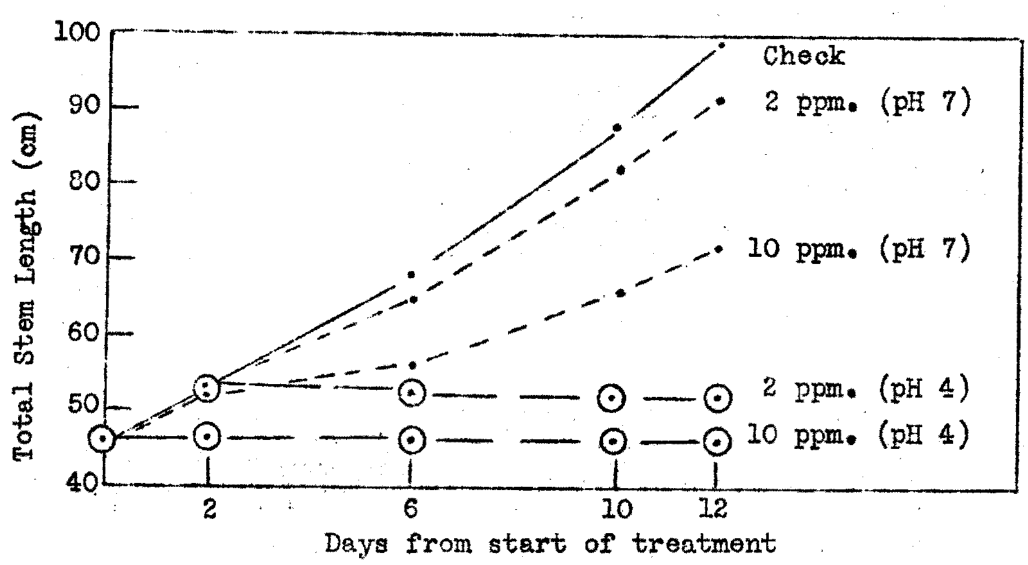

Figure 2. Stem length of soybeans in relation to pH of nutrient solution and concentration of 2,4-D in it during 24-hour exposure period (Exp. H).

plant also showed a similar trend in that a low concentration of 2,4-D seemed to increase the capacity of the leaves to hold water, but a higher concentration resulted in rapid wilting and drying out of the leaves. Each of these responses occurred at a definite time after treatment, the time of appearance not being affected by concentration of 2,4-D used. Each of these responses apparently occurred independently of the others, too.

No indication was obtained that stem elongation or capacity for active water absorption by the roots could be stimulated by 2,4-D applied in the nutrient solutions. Only an inhibiting influence was noted. The possibility exists, however, that lower concentrations of 2,4-D than were employed might have caused some stimulation of stem elongation. This response appeared soon after treatment and the effect was maintained for at least two weeks. No technique was employed which would detect increased active absorption of water by roots. Only decreased absorption was noted by failure of treated plants to bleed or to guttate. High concentrations of 2,4-D inhibited active absorption soon after treatment; lower concentrations did not produce this effect until several days later. The lowest concentrations used (2 ppm. at pH 7) caused no detectable inhibition.

The increased hydration of leaf tissues in the early stages after treatment may have been related to the water-absorbing capacity of the roots. In contrast, the rapid drying of leaves of plants given the highest concentration of 2,4-D may have been associated with injury to roots. Effects on active water absorption by high concentrations of 2,4-D were correlated with other responses, also, such as lack of proliferation of roots in stems, or lack of swelling of laterals in the roots.

The curving of stem tips was the only response which was not inhibited by any concentration of 2,4-D employed, even when the highest concentration (50 ppm. at pH 4.2) caused complete drying of the leaves within less than 3 days. This unique behavior needs further study.

CONCLUSION

When soybean plants were treated with 2,4-D added to nutrient solutions in which the plants were growing, responses occurred which suggested that a rapid systemic distribution of 2,4-D within the plant followed absorption of the compound by the roots. The pH of the nutrient solution during exposure to 2,4-D influenced the intensity of responses shown, presumably by influencing the rate of absorption of the compound.

Both stimulating and inhibiting effects were noted. Different concentrations of 2,4-D were required to produce different responses. A number of responses were produced by a certain minimum concentration, but inhibited by a higher concentration of 2,4-D. Responses generally occurred independently of each other, although the loss of capacity for active water absorption by roots may have affected the water economy of the plant.

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A Field Technique for Screening New Herbicides

Richard J. Aldrich[1]

An extremely large number of chemicals were released as experimental herbicides in 1950.

With this ever increasing number of herbicides appearing each year some method for field screening the promising ones is needed.

The following technique employed by the New Jersey Agricultural Experiment Station for the last 2 years is a means of securing preliminary information on a large number of materials.

In the 1950 tests, 53 of the more important field and vegetable crops were planted in single rows 300 feet long and 42 inches apart. Strips 3 feet in width of the experimental herbicides were applied at right angles to the rows crossing all 53 species. A one foot border between pre-emergence plots and a 3 foot border between post-emergence plots was used as a check. Thirty-nine pre-emergence and 10 post-emergence treatments were made in 1950. For most chemicals a wide range of rates of application was used to be certain that minimum and maximum rates were included. 2,4-D amine at 1½ pounds per acre pre-emergence was included as a check against the weed killing potentialities of the pre-emergence materials. The extent and duration of weed control and the weed species controlled was recorded for each treatment.

The effect of pre-emergence treatment on crop emergence and subsequent growth was recorded for each treatment. Crop injury ratings and the type of injury were made for post-emergence treatments.

It is not possible to discuss each chemical individually, but a few which looked particularly good will be discussed briefly. Pre-emergence applications of the amine salt of dinitro-ortho-secondary-butylphenol (Premerge) provided excellent control of crabgrass (*Digitaria* sp.), lamb'squarters (*Chenopodium album*), and redroot pigweed (*Amaranthus retroflexus*) at 2, 4, and 8 pounds per acre. The 8 pound per acre rate was excessive for most crops but the 2 pound per acre rate provided quite satisfactory weed control without seriously damaging several of the crops. Pre-emergence applications of sodium 2,4-dichlorophenyethyl sulfate (Experimental Herbicide #1) also provived excellent weed control and did not appear to be as toxic to crops as was 2,4-D. American Chemical Paint ACP 646-A at 2 pounds per acre gave visibly better weed control than 1½ pounds of the amine 2,4-D per acre. The extent of crop injury and the crop species injured with the ACP 646-A were essentially the same as those affected by 2,4-D amine treatments.

This rather simple screening test provides considerable information on the weed killing potentialities of a large number of materials in most of the more important field and vegetable crops. From the test the more promising materials are chosen for more detailed study the following year.

SOME NEW 2,4-D POLYETHYLENE GLYCOL DIESTERS

L. J. King and J. A. Kramer, Jr.[1]

Introduction

The value of the lower aliphatic esters of 2,4-D and 2,4,5-T in weed control is well known. However, these esters are sufficiently volatile to produce injury on unsprayed plants from vapor drift so that their use is necessarily restricted, in many instances by law. Investigators have turned their attention to esters of low volatility in an attempt to avoid this hazard. One of the difficulties involved is finding esters of low volatility which at the same time contain enough 2,4-D per pound of ester to be commercially feasible. This report is concerned with the polyethylene glycol diesters of 2,4-D and 2,4,5-T which meet these requirements.[2] When these esters are sprayed on plants they perform similarly to the esters now in commercial use. Unlike the currently used esters, these polyethylene glycol diesters will not cause vapor damage to near-by sensitive plants even if a sprayed and an unsprayed plant are enclosed in the same container.

Materials and Methods

The diesters tested were: polyethylene glycol 200 bis 2,4-dichlorophenoxyacetate; polyethylene glycol 200 bis 2,4,5-trichlorophenoxyacetate and polyethylene glycol 300 bis 2,4,5-trichlorophenoxyacetate. These diesters are soluble in both acetone and xylene. PEG 200 2,4,5-T and PEG 300 2,4,5-T are solids and the PEG 200 2,4-D is a liquid (Table 1). The PEG diesters were tested for their effectiveness in comparison with the butyl esters of 2,4-D and 2,4,5-T and the triethanolamine salt of 2,4-D on an acid equivalent basis. Their effects were studied in the cucumber root suppression test of Ready and Grant (Bot. Gaz. 109:39-44, 1947), on growth of greenhouse tomato plants when sprayed, on Japanese honeysuckle (*Lonicera japonica* Thunb.) in the field, and in controlling weeds in large field plots of field and sweet corn at Bridgeton, New Jersey (Seabrook Farming Corporation). Possible injury due to vapor was studied by confining unsprayed tomato plants with sprayed tomato plants in a large glass container. In all greenhouse tests the esters were dissolved in acetone and the solution emulsified in water, but for field tests the PEG diesters were dissolved in an oil, xylene, mixture and emulsified in water.

Results and Discussion

In a test for possible injury from vapor of the three diesters, 0.05 per cent solutions were sprayed on tomato plants and the sprayed plants placed side by side with unsprayed plants in large glass chambers (45.8 liters). For comparison the butyl esters of 2,4-D and 2,4,5-T were included in the test. Two unsprayed plants placed in a chamber served as controls. Plant heights were measured at the time of spraying, seven and fourteen days after spraying. The plants were kept in the

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1/ Boyce Thompson Institute, Yonkers, New York

2/ Compounds prepared by the Organic Synthesis Fellowship, Mellon Institute, Pittsburg, Pennsylvania, sponsored by Carbide and Carbon Chemicals Division of Union Carbide and Carbon Corporation, New York 17, N. Y.

closed chambers for seven days and thereafter in a greenhouse. The results are given in Table 2. They demonstrate a lack of hazard from vapor from the three diesters.

The results in the cucumber root suppression test of Ready and Grant are given in Table 3. It is seen that the PEG 300 2,4,5-T diester and the butyl ester of 2,4,5-T are similar in their effect. The PEG 200 2,4,5-T diester was equal to the butyl ester of 2,4,5-T at 10, 1.0 and 0.1 but not at 0.01 p.p.m. In a comparison between PEG 200 2,4-D diester and the butyl ester of 2,4-D the amount of suppression in root length was identical at the higher concentrations but somewhat greater with the PEG 200 2,4-D diester at the lower concentrations.

When the effect of sprays on potted tomato plants of PEG 200 2,4-D diester and the butyl ester of 2,4-D were compared, results shown in Table 4 were obtained. At 0.1 and 0.01 per cent the PEG 200 diester was about as injurious as the butyl ester. At 0.001 per cent the butyl ester was more inhibitory.

Field tests on Japanese honeysuckle were conducted using the PEG 200 2,4-D diester and the PEG 200 2,4,5-T diester and a combination of the two. The formulation concentrate was made up at the rate of 4 lb. of acid equivalent per gallon of formulation. The rate of application was two quarts of formulation per 100 gallons of water per acre. Observations show that after three months the 50-50 combination gave better results than when the diesters were applied singly. In the plots with the single diesters little difference could be noted in the effectiveness of the two.

The PEG 200 2,4-D diester and the amine salt of 2,4-D were compared in a large scale field test with both field (Var. U.S. No. 13) and sweet (Var. Golden Cross) corn. Each plot consisted of six 200 foot rows. The herbicides were applied on separate plots on the day of planting, four days and seven days after planting. Weed counts were made 28 days after planting by counting the number of broadleaf and grass weeds within a six-inch square over twenty-four randomized sections of each plot. The data given in Table 5 show that the PEG 200 2,4-D diester was similar to the amine salt of 2,4-D in the control of boradleaved weeds. When the applications were made seven days after planting, somewhat better control of the grass weeds was obtained with the PEG 200 2,4-D diester. The control of grasses was better when the plots were treated seven days after planting. The 2,4-D amine plot at 1 lb. per acre seven days after planting showed the typical onion-leaf effect to the corn as also did the diester, but to a somewhat lesser degree.

Summary

Polyethylene glycol 200 bis 2,4-dichlorophenoxyacetate, polyethylene glycol 200 bis 2,4,5-trichlorophenoxyacetate and polyethylene glycol 300 bis 2,4,5-trichlorophenoxyacetate have been tested for herbicidal effectiveness. The outstanding feature of the diesters is their lack of hazard from vapor to unsprayed plants. They compare favorably in toxicity with the 2,4-D compounds in greenhouse and field tests.

Table 1. Physical Properties of the Polyethylene Glycol Diesters

	Polyethylene glycol 200 bis 2,4-dichlorophenoxyacetate	Polyethylene glycol 300 bis 2,4,5-trichlorophenoxyacetate	Polyethylene glycol 200 bis 2,4,5-trichlorophenoxyacetate
Abbreviation	PEG 200 2,4-D diester	PEG 300 2,4,5-T diester	PEG 200 2,4,5-T diester
Specific gravity	1.365	1.384	-
Refractive index 20°C.	1.5440	1.5440	-
Viscosity 100°F. Centistrokes	1.032	2.663	-
Solidification range, °C.	0 to 5	0 to 3	-
Vapor Pressure, mm Hg. at 25°C.	<0.01	<0.01	<0.01
Acid equivalent	65.0%	65.8%	75.7%
Melting Points	-	20 to 25°C.	127 to 132°C.

Table 2. Results of Tests to Determine Whether Vapor from Sprayed Plants Affects Growth of Unsprayed Tomato Plants Confined in the Same Closed Container.

Ester	Average height in centimeters After 7 days Sprayed	Average height in centimeters After 7 days Unsprayed	After 14 days Sprayed	After 14 days Unsprayed	Injury Rating* After 14 days Sprayed	Injury Rating* After 14 days Unsprayed
Butyl ester 2,4-D	1.0	3.5	1.0	3.5	E	E
PEG 200 2,4-D diester	1.5	2.5	1.5	8.5	E	A
Control		3.5		10.2		A
Butyl ester 2,4,5-T	1.0	1.5	1.0	2.0	E	E
PEG 300 2,4,5-T diester	1.0	2.5	1.0	8.5	E	A
PEG 200 2,4,5-T diester	1.5	3.5	1.5	8.7	E	A
Control		2.5		8.5		A

*A = uninjured
E = dead

Table 3. Comparative Effectiveness of the Polyethylene Glycol Diesters with the Butyl Esters in the Cucumber Root Suppression Test.

Ester	Average root length in cm. at various concentrations in p.p.m. 10	1.0	0.1	0.01	0.0
Butyl ester 2,4,5-T	0.6	1.1	1.9	2.4	
PEG 300 2,4,5-T diester	0.6	1.2	2.0	2.4	2.9
PEG 200 2,4,5-T diester	0.7	1.4	2.3	3.0	
Butyl ester 2,4-D	0.7	0.6	1.0	1.2	2.5
PEG 200 2,4-D diester	0.7	0.6	0.7	0.8	

Table 4. Effectiveness of Sprays of PEG 200 2,4-D Diester and 2,4-D Butyl Ester in Retarding the Growth of Potted Tomato Plants.

Ester	Concentration %	Growth in cm. and injury rating* after 7 and 14 days			
		Growth		Injury	
		7 days	14 days	7 days	14 days
Butyl ester 2,4-D	0.1	3.0	3.0	D	E
	0.01	4.5	4.5	D+	E
	0.001	6.5	7.7	C	C
PEG 200 2,4-D diester	0.1	4.0	4.0	D	E
	0.01	5.0	8.0	C-	C-
	0.001	10.0	13.2	B-	B-
Control		5.5	18.0	A	A

*A = uninjured
E = dead

Table 5. Weed Control in Field and Sweet Corn by the PEG 200 2,4-D Diester.

Chemical	Rate in lbs. per acre.	Days after planting when applied	Number of weeds per square foot			
			Field corn		Sweet corn	
			Broadleaved weeds	Grass weeds	Broadleaved weeds	Grass weeds
2,4-D amine salt	1	0	4.2	4.3	3.2	2.5
PEG 200 2,4-D diester			4.5	2.3	2.8	2.3
2,4-D amine salt	1	4	0.3	0.5	1.2	1.5
PEG 200 2,4-D diester			0.0	0.5	0.0	0.8
2,4-D amine salt	1	7	0.8	0.8	0.7	2.7
	0.5		1.5	1.2	2.7	3.0
PEG 200 2,4-D diester	1		2.5	2.3	3.8	2.8
	0.5		3.2	2.8	3.5	3.8
Control			20.5	9.8	25.6	7.4

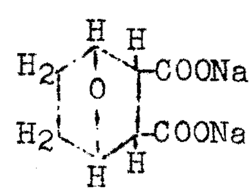
Activators Which Considerably Increase the Defoliant and the Phytotoxic Properties of Endothal

by

Nathaniel Tischler, Gorgonio P. Quimba, and Walter M. Bejuki
Sharples Chemicals Inc.

Evidence for the outstanding effectiveness of 3,6-endoxo-tetrahydrophthalic acid and 3,6-endoxohexahydrophthalic acid and several of their derivatives as defoliant-herbicides has been presented in a paper by Tischler, Bates and Quimba.(1) Additional evidence for the excellent pre-emergence control of several species of annual grasses by several of these organic compounds has been presented in a paper by Stahler.(2) Both the 3,6-endoxo-tetrahydro- and hexahydro-phthalic acids and their ionizable derivatives have produced unusual responses in plants. However, the combination of other desirable properties such as chemical stability, low toxicity to humans, readiness of preparation, and desirable handling properties has made one such derivative, disodium 3,6-endoxohexahydrophthalate, a preferred member of the two groups of compounds. This particular compound has been designated as Endothal.

A brief account of the chemistry of Endothal and of its relatives was given in the paper presented before the Northeastern Weed Control Conference.(1) The structure of Endothal is:



Although a considerable number of materials have been found which, when added to Endothal, considerably enhance its defoliant and phytotoxic properties when solutions are applied, for example by spray-misting, by deposition as droplets onto primary leaves, or by dipping plants into the solutions, this account is confined to certain of those adjuvants which show particular economic value.

Absorption Problem

First indications that the physiological effect of Endothal could be enhanced by the use of certain adjuvant chemicals was in connection with cotton defoliation experiments. It was found that several ounces per acre of a non-ionic wetting agent, Nonic 218, manufactured by Sharples Chemicals Inc. considerably increased the efficiency of Endothal as a cotton defoliant. It was not known how the wetting agent functioned to activate Endothal, but it was postulated that perhaps it increased the amount of Endothal absorbed into the plant.

Based on the finding that Nonic 218 considerably improved physiological effects of Endothal, an extensive program was undertaken to investigate many and various kinds of chemicals as adjuvants for Endothal. It was discovered by several methods of application to the top vegetation of bean plants that ammonium sulfate, ammonium bisulfate, and, in large excess, free sulfuric acid itself greatly improved the physiological effectiveness of Endothal. Subsequent work showed that the ammonium salts of nitric, hydrochloric, and phosphoric acids also markedly improved the effect of Endothal as a defoliant and as a herbicide. Thus a group of cheap industrial chemicals is available, which when formulated with Endothal significantly decrease the amount of active agent necessary to achieve the desired biological effects, either of defoliation or of weed control. These formulations make it possible to use Endothal much more economically. Based on biological effects, cost consideration, corrosive properties, and ease of handling, it was decided that ammonium sulfate offered outstanding advantages over the other cheap inorganic acids and salts.

The most significant facts concerning the use of ammonium sulfate as an adjuvant for Endothal are the type and degree of enhanced activity which is obtained. The employment of ammonium sulfate as a synergist for various chloro- and nitro-substituted phenols and alkylated phenols used as herbicides is well known. The function of the ammonium sulfate in the case of these phenolic herbicides has been ably explained by Crafts(3) and by Crafts and Reiber(4) as a chemical metathesis followed by a dissociation of the ammonium phenate into the free phenol. In this latter case, the ammonium sulfate permitted an activity to be obtained from the sodium salt of these phenolic compounds which approximated the activity obtained from the free phenolic compound per se. In the case of the addition of ammonium sulfate to Endothal, it was noted, surprisingly, that the activity which resulted was far in excess of the activity of either the free acid of which Endothal is the disodium salt, or of the mono- or diammonium salts of this free acid. Thus this increase in activity is of a degree not heretofore found when ammonium salts were employed with other herbicides and is obviously not caused by any chemical metathesis and dissociation. It is the view of the authors that it is a complex function related to the intensified absorption of Endothal by the plant surfaces.

Extensive investigations were subsequently conducted with ammonium sulfate as an adjuvant for Endothal, both in greenhouse and field experiments. Among other special problems investigated were those with reference to the optimum ratio of ammonium sulfate to Endothal. In addition, various combinations of ammonium sulfate and Nonic 218 were used at various ratios with Endothal to learn whether the wetting agent would further improve the effectiveness of Endothal. The general finding was that Nonic 218 had this effect.

Since it had been found that ammonium sulfate markedly intensified the defoliant and phytotoxic effects of Endothal when applied to the top vegetation, the question arose as to whether this inorganic salt would, likewise, increase the value of Endothal when injected into plants. For injection application, these experiments showed that Endothal formulated with ammonium sulfate is no more effective than unformulated Endothal.

In view of the above findings that formulation with ammonium sulfate appreciably increases the phytotoxicity of Endothal when applied to top vegetation, but does not increase the phytotoxicity when such combinations are injected into plants, it is evident that this inorganic salt activates Endothal by increasing the ability of Endothal to penetrate the epidermal tissues of plants to a greater degree than when applied without adjuvant to the top vegetation.

Ammonium Sulfate as an Adjuvant for Endothal

Tables 1, 2, 3 and 4 show the comparative effects of aqueous solutions of Endothal, with and without ammonium sulfate, as the result of various methods of application to the top vegetation of Dwarf Horticultural bean plants. Many experiments were conducted, and the data given are typical. These tables show that ammonium sulfate did considerably increase the value of Endothal when applied externally. Table 3 indicates that ammonium sulfate when used with Endothal at a 5:1 ratio gave better defoliant and phytotoxic effects than did a 1:1 ratio. Field plot experiments in the control of weeds in corn and experiments in which plots of turf were sprayed confirmed this finding. Other experiments at higher ratios indicated that maximum economic effectiveness was obtained at about the 5:1 ratio.

The results of experiments in which aqueous solutions of Endothal alone and ammonium sulfate plus Endothal at a 5:1 ratio were spray-misted onto young Dwarf Horticultural bean plants at 6 gallons per acre showed that 1 pound of the formulated Endothal - referred to hereafter as ME 3001 - was at least as effective in defoliation as 1 pound of the unformulated material. It is pointed out that ME 3001 contains only one-sixth the amount of Endothal present in a like weight of unformulated Endothal.

The results of these preliminary greenhouse and small field plot experiments were later closely parallelled by results obtained in cotton defoliation spray experiments during the 1950 season, repeated under different climatic conditions, over large acreages and where applications were made both by ground rig and by plane. A detailed report on the cotton defoliation work will be presented elsewhere; however, it is pointed out here that these practical cotton defoliation experiments clearly demonstrated that Endothal is an extremely potent defoliant. In Georgia, where soil and atmospheric moisture are high, 1 pound of ME 3001 per acre, in general, gave excellent defoliation; thus, the active ingredient was but 2.6 ounces per acre. Even in the relatively arid irrigated areas of the Rio Grande Valley and of Arizona where the cotton plants at harvest are vegetatively dormant to a large extent and reproductively mature and where defoliation conditions are therefore extremely difficult, 4 pounds of ME 3001 (i.e., 10.6 ounces of Endothal) per acre has in general given good defoliation. Further large scale field testing of ME 3001 showed it to be a very effective soybean defoliant at rates of application of only 1.5 to 2 pounds (i.e., 3.9 to 5.2 ounces of Endothal) per acre. At even this low dosage the top growth of bindweed vines was severely dehydrated and killed.

A Wetting Agent as an Adjuvant with Endothal

Experiments with potted bean plants in the greenhouse showed that Nonic 218 activated Endothal in top vegetation applications. Also, it was learned that when this wetting agent was used with ME 3001, it further enhanced the effectiveness of this ammonium sulfate-Endothal formulation.

Tables 5 and 5A present data of a field plot experiment with Dwarf Horticultural bean plants in the fairly mature green pod stage of development, in which the following were compared at equivalent varying dosages of Endothal: Series A - Endothal alone; Series B - ME 3001; Series C - ME 3001 plus a constant 0.1% Nonic 218. Since applications were made at the rate of 100 gallons per acre, the amount of Nonic 218 was a constant 0.8 pounds per acre. It will be noted that both the defoliant and the phytotoxic effectiveness was as follows: Series C was considerably better than Series B which, in turn, was considerably better than Series A.

The value of ammonium sulfate and of Nonic 218, used either independently or in combination, in activating Endothal was repeatedly confirmed in field plot experiments with various kinds of weeds, and in experiments in which Endothal was used in the selective control of weeds in various kinds of crops. In the latter kind of experiment, where most or a considerable portion of the top vegetation of the crops was covered by spray applications, the use of ME 3001 or of ME 3001 plus Nonic 218, considerably improved weed control, but also decreased selectivity.

Although it was learned that, in general, the use of Endothal formulated as ME 3001, with or without Nonic 218, lessened selective weed control in most crops tried, a considerable amount of preliminary experimentation indicates the practical possibilities of using such formulations in the control of weeds in corn, and also suggests the possibility of controlling weeds in cotton and in other crops where spray applications might be applied stem-directionally to contact only a small amount of the crop plants but to cover thoroughly lower-growing weed species. Space limitations do not permit tabulation of data obtained, but it is pointed out that experimentation along these lines conducted independently by Dr. Merle T. Jenkins and Dr. R. L. Lovvorn of the USDA, Beltsville, Md.; by Dr. Gilbert Ahlgren, Dr. Richard Aldrich and Mr. Willis Carson of the N. J. Agr. Exp. Sta., and by the authors clearly indicates that excellent control of both broad-leaved dicotyledenous weeds (such as purslane, pigweed and lambsquarters) and of annual grasses (such as crabgrass and foxtail) was obtained. The authors obtained excellent selective weed control in corn by applying ME 3001 plus 0.1% Nonic 218 at the rate of 4 pounds of the active ingredient, Endothal, per acre at a rate of 100 gallons per acre.

Oils as Adjuvants with Endothal

A number of field experiments, in which hydrocarbon emulsions with ME 3001 were used, have given evidence that it is possible to increase the herbicidal effectiveness of ME 3001. A special oil dispersing agent, Nonic 5063, manufactured by Sharples Chemicals Inc., was used. These oil emulsions have not only improved the phytotoxicity of ME 3001 against weed species hitherto controlled by it but have increased the list of weed species susceptible to ME 3001. In cotton defoliation field experiments in arid or semi-arid regions, the use of 1 pint of emulsified Diesel oil per acre enhanced the defoliant response obtained from a given dosage of ME 3001.

Endothal and 2,4-D Compared as to Absolute Toxicities

In order to learn the comparative absolute toxicity values of Endothal and of the sodium salt of 2,4-D, several experiments were conducted in which a constant volume (0.05 ml.) per plant of varying equivalent percentage by weight aqueous concentrations of each of the two herbicides was injected into the hypocotyls of young bean plants, approximately 6-8 inches high with the trifoliate leaves still furled. A 1 ml. Becton-Dickinson tuberculin syringe with a No. 27 one-half inch gauge needle was used for injection. The technique was to pierce a hole with the needle into the hypocotyl just above pot level, then to inject into the hypocotyl approximately one-half inch below the cotyledonary node. The purpose of the lower needle hole was to provide an air vent during injection, reduce back pressure, and thus to minimize the possibility of subsequent leakage. The general trend of results of all experiments was the same, but, for brevity, only the data from a particularly extensive experiment is presented.

The data in Table 6 show the following physiological effects of Endothal as compared with the sodium salt of 2,4-D when injected into young bean plants:

(1) Endothal causes greater lethal effects at the same weights of chemical injected into plants than does the sodium salt of 2,4-D.

(2) Endothal brings about plant kill more rapidly than does the sodium salt of 2,4-D.

(3) At sub-lethal dosage levels, the sodium salt of 2,4-D causes considerably more marked retardation of trifoliate shoot development than does Endothal.

(4) The physiological effects of the two herbicides are strikingly different: Endothal is a defoliant-herbicide; 2,4-D is a herbicide. Endothal causes burning and dehydration of leaves and of stems, depending on the amount taken in by the plant. If the amount of Endothal absorbed by the plant is sufficiently high, the plant may be severely injured or destroyed; at lower dosages, the plant is only somewhat damaged and recovers. 2,4-D also kills the plant if the intake is sufficiently high, but the initial effects, depending on the amount absorbed, are entirely different. The stem undergoes epinasty; the leaves curl; much of the stem, particularly the hypocotyl, becomes swollen and at high doses tremendously so; galls are produced in certain regions, particularly on the trifoliate shoot; and a degree of root initiation, correlated with the dosage, occurs on the lower portion of the stem.

Conclusions

1. The following chemicals used as adjuvants with Endothal markedly enhanced both its defoliant and phytotoxic properties: the ammonium salts of sulfuric, hydrochloric, nitric and phosphoric acids. Of these, ammonium sulfate has proved most suitable for practical use.

2. A wetting agent, Nonic 218, has been found to increase the effectiveness of both Endothal alone and its ammonium sulfate formulations.

3. Hydrocarbon oils, used in emulsion form with ammonium sulfate, have shown further promise of economically improving Endothal as a defoliant and as a herbicide.

4. The inherent phytotoxic value of Endothal, as indicated by comparative injection experiments into bean plants, has been found to be equal or even greater than that of the sodium salt of 2,4-D.

References

(1) Nathaniel Tischler, James C. Bates and Gorgonio P. Quimba: "A new group of defoliant-herbicidal chemicals", Proceedings of the Northeastern Weed Control Conference, p. 51-84, January 1950.

(2) L. M. Stahler, "Screening of new selective herbicides", Proceedings of the North Central Weed Control Conference, p. 95-101, December, 1949.

(3) A. S. Crafts, "A theory of herbicidal action", Science, vol. 108, p. 85-86, July 23, 1948.

(4) A. S. Crafts and H. G. Reiber, "Studies on the activation of herbicides", Hilgardia, vol. 16, no. 10, p. 487-500, May 1945.

Table 1. Deposition of several droplets onto both primary leaves[a]

Material	Kind of Effect	% Concentration 0.01	0.02	0.05	0.1
		Amount of chemical per plant (micrograms) 20	40	100	200
Endothal alone	Abscission[b]	none	none	none	none
	Leaf burn	slight	slight	light	mod.
	Inhibition[c]	none	none	none	none
Endothal plus 0.1% $(NH_4)_2SO_4$	Abscission[b]	none	3S	1B, 1S	3B, 1S
	Leaf burn	consid.	consid.	consid.	severe
	Inhibition[c]	none	none	none	slight

[a] 7 to 9 droplets (totaling 0.1 ml) per leaf. 4 young plants with undeveloped trifoliate shoots were used per test. Observations were made 8 days after treatment.

[b] Under abscission, the abbreviation 3B, 1S (as example) means that of the plants used in the test 3 plants had both and 1 plant had a single primary leaf abscised.

[c] Inhibition refers to retardation of trifoliate shoot.

Table 2. Plants dipped to first nodes[a]

Material	Kind of Effect	% Concentration 0.0025	0.005	0.01	0.025
		Amount of chemical per plant (micrograms)[b] 50	100	200	500
Endothal alone	Abscission	1S	2B, 5S	4B, 3S	8B
	Leaf burn	Moderate	Moderate	Severe	Severe
	Stem injury	None	None	Light	Consid.
	Inhibition	Light	Light	Severe	Severe
Endothal plus $(NH_4)_2SO_4$ (1:5 ratio)	Abscission	4B, 2S	7B, 1 S	8B	6B, 1S[c]
	Leaf burn	Severe	Severe	Severe	Severe
	Stem injury	None	Light	Consid.	Plants dying
	Inhibition	Consid.	Severe	Severe	Severe

[a] Abscission observations made 2 days after treatment; other observations, 10 days after treatment. 8 young plants with undeveloped trifoliate shoots were used per test.

[b] The amount of chemical per plant in terms of micrograms/plant is approximate and is based on the fact that on dipping plants of the stage designated approximately 2 ml. of solution is taken up per plant.

[c] Adhering leaves were withered and "frozen"; i.e., were so severely injured that the zones of abscission did not form.

Table 3. Plants spray-misted at rate of 6 gallons per acre (3 ml/6 sq. ft.)[a]

Material	Kind of Effect	% Concentration 0.016	0.031	0.062	0.125
		Amount of Chemical (ounces per acre) 1/8	1/4	1/2	1
Endothal alone	Abscission	None	1 S	1S	5B, 4S
	Leaf burn	Slight	Slight	Light	Light
	Inhibition	None	None	None	Moderate
Endothal + $(NH_4)_2SO_4$ (1:1 ratio)	Abscission	None	None	1B, 5S	13B, 2S
	Leaf burn	Slight	Slight	Moderate	Moderate
	Inhibition	None	None	None	Severe
Endothal + $(NH_4)_2SO_4$ (1:5 ratio)	Abscission	4S	4B	8B, 2S	13B, 2S
	Leaf burn	Slight	Moderate	Moderate	Moderate
	Inhibition	None	Slight	Slight	Severe

[a]Observations made 6 days after treatment; 15 young plants with undeveloped trifoliate shoots per test were used.

Table 4. Plants spray-misted at rate of 6 gallons per acre (3 ml/6 sq. ft.)[a]

Material	Kind of Effect	% Concentration 0.25	0.5	1	2
		Amount of chemical (ounces per acre) 2	4	8	16
Endothal alone	Abscission	None	10% PL + 15% TL[c]	35% PL + 60% TL[c]	70% PL + 85% TL[c]
	Leaf burn[b]	Slight	Light	Moderate	Consid.
	Stem burn	None	None	None	None
Endothal + $(NH_4)_2SO_4$ (1:5 ratio)	Abscission	25% PL + 35% TL	95% PL + 95% TL	98% PL + 98% TL	98% PL + 99% TL
	Leaf burn[b]	Light	Consid.	Consid.	Consid.
	Stem burn	Light	Consid.	Consid.	Severe

[a]Observations were made 10 days after treatment; 15 intermediate-sized plants were used per test.

[b]Refers to adhering leaves.

[c]PL - primary leaves; TL - trifoliate leaves.

Table 5. Field plot defoliation of maturing Dwarf Horticultural beans in the green pod stage of development[a].

Plot No. (b)	% Defoliation	Effects on adhering leaves	Effects on pods	Stem injury
A-1	1%	Slight burn	Few spotted	None
A-2	5%	Light burn	Few light burn	None
A-3	15%	Light burn	Few mod. burn	None
A-4	60%	Some shriveled	Few mod. burn	None
B-1	25%	Light to consid. burn	Top pods, mod. damage	None
B-2	40%	Most shriveled	Mod. to consid. damage	Light
B-3	75%	Most "frozen"	Mod. to consid. damage	Light
B-4	75%	All "frozen"	Mod. to consid. damage Few pods abscissed	Light
C-1	90%	Consid. burn	Light	Light
C-2	95%	Mod. to consid. burn	Light to mod.	Mod.
C-3	-	All plants shriveled and severely damaged.		
C-4	-	All plants shriveled and severely damaged.		

[a] Observations 4 days after treatment. Plots were 25 sq. ft. each (5 ft. x 5 ft.); spray applications were made with a Hudson Perfection 3 gallon knapsack sprayer at 30 lbs. pressure and at 100 gallons spray per acre.

A control plot treated with an aqueous solution containing 20 lbs. ammonium sulfate plus 0.8 lbs. Nonic 218 per acre respectively gave no effects after 10 days.

[b] See supplementary table below (Table 5A) for the formulations used in each plot.

Table 5A. Formulations of aqueous solutions of the following series:

Series A: Endothal alone
B: Endothal plus $(NH_4)_2SO_4$ at a 1:5 ratio (ME 3001)
C: As Series B (ME 3001) plus a constant amount of wetting agent (Nonic 218)

Plot No.	Endothal % conc.	Endothal lbs./A	$(NH_4)_2SO_4$ % conc.	$(NH_4)_2SO_4$ lbs./A	Nonic 218 % conc.	Nonic 218 lbs./A	Gallons per acre
A-1	0.062	0.5	none		none		100
A-2	0.125	1	none		none		100
A-3	0.25	2	none		none		100
A-4	0.5	4	none		none		100
B-1	0.062	0.5	0.31	2.5	none		100
B-2	0.125	1	0.62	5	none		100
B-3	0.25	2	1.25	10	none		100
B-4	0.5	4	2.5	20	none		100
C-1	0.062	0.5	0.31	2.5	0.1	0.8	100
C-2	0.125	1	0.62	5	0.1	0.8	100
C-3	0.25	2	1.25	10	0.1	0.8	100
C-4	0.5	4	2.5	20	0.1	0.8	100

Table 6. Comparative effects on injection of aqueous solutions of Endothal and of the sodium salt of 2,4-D into Dwarf Horticultural bean plants[a]

Amount per plant (micro-grams)	% Plants Dead						Wgt. of TS[b] (gms)		Other Physiological Effects			
	Endothal			Na Salt, 2,4-D			Endothal	Na-2,4-D	Endothal	Na Salt of 2,4-D		
	6 Days	10 Days	19 Days	6 Days	10 Days	19 Days	19 Days	19 Days	Stem injury[d]	Hypo-cotyls[d] swollen	Stem root-ing[d]	Galls[e] Trifol shoots
(Controls - untreated plants) 0	0	0	0	0	0	0	2.64	2.64	For development of controls, 19 days after starting expt. see[f]			
1	0	0	0	0	0	0	2.75	2.44	None	None	None	None
5	0	3	3	0(c)	3(c)	3(c)	2.03	1.21	None	Slight	Slight	3 Plants
10	12(c)	37(c)	41(c)	0	0	0	1.88	1.06	Light	Light	Light	7 Plants
20	44	84	84	12(c)	32(c)	42(c)	1.46	0.81	Light	Severe	Mod.	9 Plants
30	44	78	78	19	63	75	1.48	0.35	Light	Severe	Consid.	18 Plants
40	61	97	97	56	69	72	0.6	0.47	Consid.	Severe	Consid.	9 Plants
50	53	94	94	44	72	75	0.2	0.88	Consid.	Severe	Consid.	11 Plants
60	97	97	97	47	72	75	0.7	0.86	Consid.	Severe	Consid.	11 Plants
70	100	100	100	53	81	91	-	0.23	-	Severe	Consid.	12 Plants

(a) 0.05 ml of each test concentration injected into hypocotyls of young bean plants with trifoliate shoots (TS) undeveloped.

(b) Weight of trifoliate shoots (TS) of survivor plants after 19 days. (Trifoliate shoots refer to part of plant growing above the second node.)

(c) Based on 31 plants; in all other cases, based on 32 plants (when 31 plants were used, this was due to accidental plant breakage or to root-rotting.)

(d) Based on survivor plants, 19 days after treatment.

(e) Based on survivor plants with galls on trifoliate shoots (TS), 6 days after treatment.

(f) Controls (untreated) plants had 1st and 2nd trifoliate leaves large, and 3rd trifoliate leaves small, 19 days after beginning of experiment.

CHLORO IPC - A NEW HERBICIDE

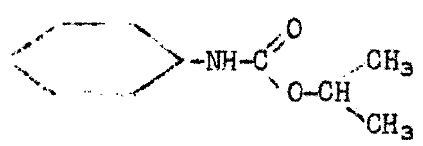
E. D. Witman and W. F. Newton

The effect of esters of carbanilic acid on the growth of plants apparently became known first to Friesson (1) in 1929. Little application was made of this discovery until 1945 when Templeman (2) found that the Isopropyl ester of carbanilic acid, also known as Isopropyl N-Phenyl Carbamate or simply IPC, was the most effective of several esters studied in retarding the growth of oats.

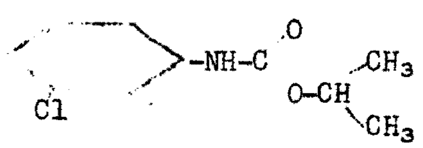
Field experimental work in the United States during the years following 1945 is resulting in the development of commercial usages for IPC for the control of certain weeds in legumes, strawberries, spinach and lettuce.

For certain applications, the residual life of IPC in the soil has been too short, however, a new derivative of IPC, called chloro IPC, has a longer residual period and a different range of selectivity and thus may compliment the known uses for IPC.

The structural relationship between IPC and chloro IPC along with their full chemical names is given diagramatically below:



Isopropyl N-Phenyl Carbamate



Isopropyl N-(3-chlorophenyl) Carbamate

Both of these compounds would be indexed in Chemical Abstracts under "carbanilic acid" since they may be regarded as esters of that acid.

From a physical standpoint, IPC and chloro IPC are quite different. IPC is a solid melting at about 87°C. while chloro IPC is a liquid, solidifying at slightly below room temperature. Too, chloro IPC is much more soluble in organic solvents than regular IPC, being miscible in all proportions with short chain aliphatic alcohols, aromatic hydrocarbons and various ethers and esters. Chloro IPC is only about 10% soluble in kerosene and other aliphatic hydrocarbons. The greater solubility of chloro IPC in organic solvents allows easier compounding of this substance into liquid emulsifiable formulations.

It is improper at this time to try to delineate the value of this new herbicide since only little is known concerning its effectiveness under field conditions. However, it may be generally described as a chemical showing possibilities of developing into a selective herbicide with greater residual activity than regular IPC and with a somewhat modified range of selectivity. It appears that the key to effective use of this new substance lies in applying it to soil when seeds of the plants to be controlled are about to germinate or established plants are in the small seedling stage.

Many samples were distributed throughout the United States in 1950 and more are available for qualified investigators for 1951. Accumulation of data from such sources should certainly determine the future usefulness of chloro IPC as a selective herbicide.

(1) Friesson, Planta Abt. E., Z. wiss. Biol. 8, 666-79 (1929)
(2) Templeman, Nature 156, 630 (1945)

Further Testing of Herbicides in Strawberry Plantings

by
R. F. Carlson and J. E. Moulton[1]

In the past six years 2,4-D has been used experimentally and to some extent commercially for selective control of many broad-leaved weeds in strawberry plantings (1, 2 and 8). It has further been reported (3, 4) that IPC can be used to control chickweed in strawberries. In preliminary tests (5, 6 and 7) commercial preparations known as Experimental Herbicides 1, 2 and 5722 have given selective control of weeds. The purpose of the tests reported here was to compare the effectiveness of some of these materials as herbicides and to get information on their possible future use in strawberry plantings.

Materials and Methods

One acre of land with a Hillsdale sandy loam soil was planted May 20 with the Premier strawberry. The rows were spaced three feet apart, and randomized 50-foot row sections were laid out for each treatment and replicated four times. The planting was cultivated at regular intervals conforming to the standard practice of strawberry culture.

Five materials were used as follows: 2,4-D at ½ and 2 lbs. per acre; IPC at 5, 10 and 15 lbs.; EH 1, (Sodium 2,4-dichlorophenyl "cellosolve" sulfate) at 2, 3 and 4 lbs.; EH 2, (Dichloral Urea) at 3, 6 and 9 lbs.; and EH 5722 at 1, 2 and 3 lbs. per acre. Two applications were made; the first one came June 4, 15 days after planting and the second July 18, six weeks later. Some weeds had emerged at the time of the first application. Since the first application of EH 5722 did not affect the weeds or strawberry plants, the second application was doubled to 2, 4 and 6 lbs. per acre. All materials were applied in a 2-foot band over the row with a knapsack sprayer at the rate of 50 gallons per acre.

Weed control was measured by counting the weeds per square foot, and four counts being taken per treatment, on two different dates, June 28 and August 15. After each count, the remaining weeds in all treatments were removed by hoeing and the time required to hoe the weeds was recorded for each treatment. On September 27 the effects of the various chemicals on runner production was determined by counting the runners on five plants in each treatment to obtain an average of all replications. Since this was a first year planting all blossoms were removed by hand and consequently no yield records were obtained.

The weed population encountered in this area was made up of a number of common weeds that create a problem in strawberry growing. Some of these were: Rough pigweed (<u>Amaranthus retroflexus L.</u>), common ragweed (<u>Ambrosia elatior L.</u>) and Downy-brome-grass (<u>Bromus tectorum L.</u>). The common chickweed (<u>Stellaria media L.</u>) was not present in this planting.

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Results

Effects of 2,4-D: The herbicide 2,4-D at 2 lbs. per acre controlled 95 per cent of the weeds, whereas, ½ lb. per acre gave 55 per cent control from the first application (Table I). Some of the weeds had emerged at the time of the first application and they were killed at the low concentration, but at the higher rate the seeds that were germinating in the soil as well as the young seedlings were destroyed. Both rates retarded the growth of the strawberry plants and some reduction in stand was observed at the two pound rate. Tolerance was measured by the number of runners produced during the season. The number of runners was reduced by 46 per cent at the ½ pound rate and by 91 per cent at the 2 pound level. This reduction in runners has not been observed when one application of the herbicide was made early in the first year bed or in the second year bed (1, 2). Apparently two applications of 2,4-D that close together, or at the time (July 18) when runners are initiating will result in fewer runner plants. Or the reduction in runners perhaps was due to the persistance of 2,4-D from both applications as reported for woody plants (9). Aside from runner reduction the plants appeared normal at the end of the first growing season.

Effects of IPC: Because some of the weeds had already emerged when the IPC was applied it did not control the weeds satisfactorily. For maximum control this material should be applied just at or prior to germination of most weed seed (4). The only apparent injury to the strawberry plants was the reduction in runners compared to the check plots (Table I).

Effects of EH 1: Control of weeds with EH 1 at 4 lbs. per acre was equal to 2 pounds of 2,4-D and superior to all other materials used in these tests (Table I). EH 1 at 2, 3 and 4 pounds per acre gave 64, 72 and 84 per cent control of weeds respectively. Where the weed population is such that larger dosages of EH 1 is required the rate can be increased to 6 pounds per acre without apparent injury to the strawberry plant (5). According to prior work EH 1 is most effective as a seed toxicant and perhaps better control of weeds in these tests would have been obtained if the material had been applied approximately five days after setting the strawberry plants rather than 17 days following planting. No epinastic or formative effects were observed and the plants appeared normal at all concentrations throughout the growing season. The runner production in all treatments with EH 1 was equal to that in the check plots.

Effects of EH 2: From casual observations it appeared that EH 2 had very little effect on either weeds or strawberry plants, however, the records reveal that some weeds were killed and that runner production was greatly reduced, especially at the high concentration of nine pounds per acre. Downy-brome-grass was controlled in these tests, whereas, the broad-leaved weeds were not affected so much at these concentrations.

Effects of EH 5722: Under the conditions of these tests EH 5722 did not give satisfactory control of weeds. When the concentrations were doubled (from 1, 2 and 3 to 2, 4 and 6 pounds per acre respectively) for the second application the foliage of the strawberry plants was "burned" resulting in a reduction in their growth as well as a reduction of runners. The plants appeared normal by the end of the season. Both EH 2 and EH 5722 apparently are very effective substances in preventing runner production which might have a practical application where the hill system of growing plants is practiced.

Effect of materials in reducing labor: Accurate records were taken of the time spent in eliminating weeds by hand weeding and hoeing in all treated and check plots. Where 2 pounds of 2,4-D was used a little over one day per acre was spent in eliminating the remaining weeds during the season of the first year planting. Compared with the check the new herbicide EH 1 at 4 pounds per acre reduced the hand labor from 63.3 hours to 18.8 hours per acre. The 2 and 3 pound rates were also satisfactory in this respect. The other materials used, although reducing labor to some extent, were not as effective (Table I.).

Table I. Per Cent of Weeds Eliminated with Herbicide and Runner Production Compared to Untreated Plots; Man-hours of Hoeing per Acre Required Following Treatment.

Materials	Pounds Per Acre Applied June 4 and July 18	Per Cent Runners	Per Cent Weed Control		Man-hours of Hoeing Per Acre		
			1st Count	2nd Count	1st Hoeing	2nd Hoeing	Total
2, 4-D	½	54	55	80	18.9	5.0	23.9
2, 4-D	2	9	95	84	8.3	1.6	9.9
EH 1	2	94	52	64	23.9	6.1	30.0
EH 1	3	109	66	72	16.1	4.4	20.5
EH 1	4	94	83	84	14.4	4.4	18.8
EH 2	3	45	2	4	35.8	11.6	47.4
EH 2	6	18	8	52	33.3	6.6	39.9
EH 2	9	4	32	52	30.0	5.3	35.3
IPC	5	67	10	8	36.0	13.3	49.9
IPC	10	54	19	20	31.1	10.0	41.1
IPC	15	31	24	36	30.0	8.3	38.3
EH 5722	1	41	33	6	36.4	12.3	48.7
EH 5722	2	23	36	10	34.2	11.6	45.8
EH 5722	3	4	42	24	30.6	7.2	37.8
Control	0	100			43.3	20.0	63.3

Summary

In the spring of 1950 five herbicides, at three concentrations of each, were used in a newly set planting of the Premier strawberry variety. A second application of the same materials was made six weeks after the first. Weed counts were made September 27. Since no fruit was harvested the first season, no yield data was recorded.

Satisfactory weed control was obtained where 2 pounds per acre of 2, 4-D was used, whereas, the ½ pound rate did not control all the weeds. Retardation of plants was observed, and because the second application came at a critical period when runners were being initiated, runner production was greatly reduced with 2 pounds of 2, 4-D. Timing the application so that the material will not interfere with the normal growth processes of flower bud initiation and general plant development is important, especially when hormone-like materials are used.

The new material EH 1 gave 58, 69 and 84 per cent weed control (based on check) at 2, 3 and 4 pounds per acre respectively. The strawberry plants appeared as vigorous, or more so, then the checks during the first growing season. No significant reduction in runners was recorded at any level of EH 1. Completed tests indicate that EH 1 at 3 or 4 pounds per acre can be used safely for weed control twice or more during the growing season.

Under the conditions tested the materials IPC, EH 2 and EH 5722 did not show so much promise in weed control in strawberries as did EH 1 and 2, 4-D (Table I.). Some burning of the foliage was observed from the second application of EH 5722. Runner production was reduced with these materials.

Hand labor was reduced by two-thirds where EH 1 and 2, 4-D were used, and by about one-third with the other materials.

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PROGRESS OF STRAWBERRY WEED CONTROL IN VIRGINIA

Simultaneous Control of Winter Weeds and Two Spotted Spider Mite In Blakemore Strawberries With Dinitro Ortho Secondary Amyl Phenol

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Control of winter weeds such as henbit (Lamium amplexicaule) and chickweed (Stellaria media) in strawberry plantings is a major production problem in Tidewater Virginia. Recent unseasonably warm winters have aggravated the weed problem and have been conducive to the development of large populations of red spider - or two spotted spider mite (Tetranychus bimaculatus Harvey). Results obtained with 75% dinitro ortho secondary amyl phenol (Sinox General) as a weeding agent have proved quite encouraging. It was found concurrently that this chemical applied in herbicidal concentrations was also highly toxic to red spider (5) (7). These considerations because of their economic importance to this area and other areas of like climate and because of their general interest form the basis of this report.

Crop Tolerance

Preliminary observational trials were conducted in the winter of 1945-46 on the use of a contact weed-killing chemical, namely, sodium dinitro ortho cresylate (Sinox)1/ as a means of controlling chickweed and henbit in Blakemore berries. These trials applied on the growing weeds were not successful in controlling the weeds but results showed that the berry plants were quite tolerant of radical defoliation with chemicals during dormancy. This tolerance suggested that the use of a chemical of greater phytotoxicity might give practical weed control without causing permanent injury to the crop. Trials conducted during the intervening years with dinitro ortho secondary amyl phenol (Sinox General)1/ hereinafter abbreviated to DNOSAP for convenience, have shown this to be true.

This tolerance of radical defoliation during dormancy is not a new consideration in this area because it has been a practice in some localities to burn off the accumulated growth of late summer grasses on berry fields during the winter. This practice is not without hazard, but crop injury is avoided if a fair wind is blowing during the burning as this causes a quick sweep of the fire and prevents excessive local temperature build-up.

The following discussion of the use of DNOSAP and the very promising results obtained are presented with observations on possible cause and effect relationships.

Plant Structures and Rate of Application Related to Tolerance.

Examination of berry plants sprayed with DNOSAP during the course of these trials has indicated that tolerance was closely related to structure. The

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1/ Standard Agricultural Chemicals, Inc. Material supplied through courtesy of this company.

imbricated sheaths which cover the leaf and fruit buds protected the growing point from contact by the herbicide when it was applied at concentrations sufficient to kill the winter weeds in their early growth stages. Rates of application above that required to accomplish this tended to eliminate the selective tolerance of berry plants and weeds. The perennial nature of the berry ensured regeneration of the destroyed foliage when the vegetative primordia had not been injured.

Trials have indicated that the maximum rate of application should be approximately 100 gallons per acre of a solution containing one quart of 75% DNOSAP and 15 gallons of kerosene, though much higher rates have been applied in field areas without injury to the crop. Crop vigor and weed cover have much to do with rate of application tolerated and the above maximum is based on these considerations and the avoidance of injury in virtually all cases.

Plant Development Related to Tolerance.

Applications of DNOSAP at various times from early fall to late spring have shown that severe injury may result from ill-timed spraying with the normal weed killing concentrations. Early fall applications remove foliage before fruit bud development has been completed thus cutting short the storage of reserves for fruit production in the spring. Fruit bud development is usually completed in this area by the end of October and is signified by the red or purple coloration of the berry plant leaves which indicates dormancy for all practical purposes in this work. Yield results on plots sprayed during dormancy are given in Table I and show that yields were not reduced by such treatments.

Table I. Yield Record Summary Prior to 1950 Harvests
Showing Effect of Using DNOSAP on Dormant Blakemore Strawberries

Date Treated*	Plot Size	No. Reps.	Av. Yield Crates Per Acre		Treated % Control
			Control	Treated	
12/19/47	1/100 A.	4	139.5	132.7	95.1
10/26/48	1/58 A.	4	86.6	93.5	107.9
11/16/48	1/58 A.	4	72.3	68.8	95.1
1/14/49	1/100 A.	4	101.3	112.5	111.0

* Hand sprayed with knapsack pump-up sprayer. Standard treatment 100 gallons per acre containing one quart of 75% DNOSAP and 15 gallons of kerosene.

During winters when freezing weather is not experienced until very late, if at all, as in 1949-50 when dormancy coloration occurred the first week of March, the question of treatment timing may be answered by the setting of more-or-less arbitrary dates during which treatment should be completed in this area. The yield results contained in Table II show that applications of herbicidal strength made throughout the winter period did not affect yield adversely in this atypical warm winter. These results may seem contrary to the foregoing discussion but may be explained on the basis of reduced anabolism or the slowing down of the plant's carbohydrate accumulating activities as average diurnal temperatures, light intensities and light duration are reduced, thus placing the leaves on a subsistance basis or even causing them to draw on the carbohydrate reserves of the plant. These speculations based on observation and yield results would indicate that dormancy might be considered as starting approximately the 1st of November in this area.

Table II. Yield Record Summary of 1950 Harvest Results
Showing Effect of Time of Application of DNOSAP on Blakemore Strawberries
(Assembled from experiments at various locations)

Date Treated*	Plot Size	No. Reps.	Av. Yield Crates Per Acre		Treated % Control	L.S.D. 5%
			Control	Treated		
11/17/49	1/56 A.	5	54.6	65.4	119.8	4.2
1/12/50	1/55 A.	5	54.6	51.4	94.1	4.2
2/1/50	1/4 A.	3	125.0	129.5	103.6	N.S.
2/21/50	1/100 A.	4	65.9	54.1	82.1	14.7
3/11/50	1/100 A.	3	114.1	132.2	115.9	16.5

* All treatments sufficiently concentrated 75% DNOSAP to completely defoliate berry plants.

Spring applications of DNOSAP may also cause crop injury unless timed correctly. In general, sprays of herbicidal concentrations of the chemical after the 1st of February are considered hazardous as they may destroy the flowers which set the early fruit. Yields have been reduced as much as 50 percent in areas sprayed just following the start of rapid growth in the spring. Sprays applied one week prior to this were not injurious.

The question of the effect of herbicidal concentrations of the chemical on first and second year berry fields has arisen and results obtained with large areas have indicated that yields have not been affected by single spray applications per year in either case.

Weed Control

As indicated in the foregoing discussion, it has been established that the dormant Blakemore strawberry plant is quite tolerant of herbicidal concentrations of DNOSAP. This has made it possible to obtain control of single populations of chickweed and henbit during the winter dormant or semi-dormant period of the berry plant.

Timing Applications to Get Maximum Control.

Control of these two weed species was most easily obtained if they were sprayed when they were less than 2 inches tall or, at the latest, prior to branching.

Duration of control was dependent on the weather since it was found that a single application of DNOSAP in early December in a normally cold winter gave control of these weed species throughout the entire winter, whereas, applications made at the same time in warm winters have only given control for one to two months due to the successively emerging populations of these weeds.

Rate of Application and Control.

The rate of application required to give practical weed control was found to be dependent on the amount of weed foliage, or weed population, and the developmental stage of the weed plants. Results showed that practical control could be obtained by spraying prior to branching of the weeds and that it becomes increasingly difficult to obtain control as the weeds advance beyond this stage. With these considerations in mind, it was found that a standard spray solution containing one quart of 75% DNOSAP and 15 gallons of kerosene in enough water to make a volume of 100 gallons, applied in sufficient quantity to thoroughly wet the weed foliage, gave satisfactory control during the early stage of weed growth.

A milder spray solution, containing one quart of 75% DNOSAP and 6.5 gallons of kerosene in enough water to make 100 gallons volume, gave satisfactory control of these weed species when good coverage was obtained and the weeds were less than one inch tall. An application of 25 gallons per acre of this mixture appeared to be a minimum effective rate.

Yield results given in Tables I, II, and III show that permanent injury to the crop did not occur from any of the spray applications made under the various conditions indicated above.

Table III. Yield Summary of 1950 Trials Showing Effect of Rate of Application of DNOSAP on Dormant Blakemore Strawberries

Rate of Application* Gals./Acre	Av. Yield** Crates/Acre	Yield % Control
Control	125.4	---
25	137.4	109.6
50	119.1	94.9
100	129.5	103.2

* Treated February 21. Plot Size - 0.25 acre. 3 Replications. Standard spray solution containing one quart of 75% DNOSAP and 6.5 gallons of kerosene in enough water to make 100 gallons volume used in all rates of application.
** Differences did not show significance at the 5% level.

Field Plot Procedure and Results.

Replicated randomized small plots of not less than 0.01 acre which were sprayed with a knapsack pump-up sprayer were used in the initial experimental determinations and have been a continuing part of the program. The oil emulsion spray was agitated by a continual movement of the sprayer tank during application to ensure equal distribution of the active agents. Results of these small trials are given in Tables I and II. Larger plots of 0.25 acre were sprayed in a randomized experiment in the winter of 1949-50 on which yield results are reported in Table III.

Grower observations of results obtained in the small trials led to the early spraying of large acreages though treatments were suggested for small trial only. Observation of these large acreages, amounting to 600 acres in this area in the winter of 1948-49, and the concurrently sprayed experimental plots have provided a broad general background of experience which has been set forth in the preceding sections. The summation of this experience to date indicates that it is relatively safe to apply single sprays per season of threshold herbicidal concentrations of DNOSAP to Blakemore strawberries during the dormant period.

It is felt that results obtained to date, though very encouraging, must be accepted only as indicative of what the chemical may accomplish. More information on climatic effects, time of application as it affects crop tolerance, and the refinement of methods of application are being sought in trials now being conducted in a continuation of this work.

Control of the Two Spotted Spider Mite

The two spotted spider mite (Tetranychus bimaculatus Harvey), or red spider as it is commonly called, is the most serious pest of strawberries in southeastern Virginia. These mites feed by sucking the sap from the plants and cause a general loss of vigor, reduced yield and permanent stunting or death. Normally most of the damage to plantings occurs in late spring and during harvest. However, in unusually mild winters such as 1948-49 and 1949-50 the red spiders continue to feed, multiply and injure the strawberry crop throughout the winter. For the most part low soil surface temperatures, cool nights and variable weather conditions make it extremely difficult to obtain satisfactory insecticidal control in winter or early spring. It was reported by Hofmaster and Greenwood (6) that, although late spring infestations can be fairly well controlled with dusting sulfur, parathion or tetraethyl pyrophosphate, 3 to 4 applications are usually necessary. In addition to the number of applications required, all of the insecticides recommended for use in this area have one or more of the following limitations; general ineffectiveness and foliage injury under certain weather conditions; difficulty in timing applications properly; a high mammalian toxicity; and the time and cost involved in treating.

In the 1948-49 weed control trials with DNOSAP, Danielson (5) observed that strawberry plants treated with this chemical were virtually free of red spiders whereas adjacent untreated areas were heavily infested. Subsequent examination of a number of widely separated commercial fields gave evidence to support the observations made on the trial plots. This possible toxic effect of DNOSAP to the red spider formed the basis for a detailed field study during the winter of 1949-50. The results are presented here.

Small Scale Tests.

A series of preliminary tests designed for the primary purpose of developing a satisfactory method of evaluating the effectiveness of DNOSAP sprays to the two spotted spider mite was begun at Churchland, Virginia, December 19, 1949. Non-replicated plots of 0.01 acre were treated by means of a knapsack sprayer operating in a pressure range of 30 to 50 lbs. per square inch. A standard spray solution consisting of 1 quart 75 percent dinitro ortho secondary amyl phenol, 6.5 gallons kerosene and water to make 100 gallons was applied at 25, 50 and 100 gallons/A. Variations in rates were obtained by keeping the pump pressure constant and changing the rate of movement of the operator. The effects of the treatments were determined by selecting a given number of infested leaves, extracting a 0.3 square inch leaf plug from a heavily infested area and counting all living and dead mites. In counts taken later than one week after treatment the leaves were selected at random and only the living mites recorded. The results of a representative series of these tests as presented in Table IV A show that DNOSAP was effective in reducing red spider populations. The method of evaluation presented here proved highly satisfactory and was adopted in subsequent experiments.

Table IV. Results of Treating Blakemore Strawberries with DNOSAP for Two Spotted Spider Mite Control

A. Non-Replicated Preliminary Tests. Churchland, Virginia. 12/19/49.

Gals. Spray Per Acre*	Number Mites per 20 (0.3 sq. in.) Samples			
	1/4/50		1/23/50	
	Alive	Percent Reduction	Alive	Percent Reduction
25	38	81.0	25	91.3
50	28	86.0	10	96.5
100	4	98.0	8	97.2
0	200	--	289	--

B. Replicated Preliminary Tests. Norfolk, Virginia. 1/23/50.

Gals. Spray Per Acre*	Mean No. Mites per 50 (0.3 sq. in.) Samples							
	1/25/50			1/27/50			3/23/50	
	Alive	Dead	Percent Dead	Alive	Dead	Percent Dead	Alive	% Red.
25	138.0	1377.3	90.9±.88	44.0	1405.7	97.0±.39	260.0	48.0
50	10.3	1451.3	99.3±.16	7.0	1368.0	99.5±.23	45.7	90.9
100	4.7	1443.0	99.7±.12	2.0	1441.3	99.9±.023	11.0	97.8
0	1404.3	92.0	6.1±.56	1380.0	90.7	6.2±.74	499.7	--
L.S.D. 5%							93.2	

C. Replicated Field Tests Using Power Spray Equipment. Churchland, Va. 2/1/50

Gals. Spray Per Acre*	Mean No. Mites per 100 (0.3 sq. in.) Samples							
	2/3/50			2/6/50			3/20/50	
	Alive	Dead	Percent Dead	Alive	Dead	Percent Dead	Alive	% Red.
25	47.0	2774.7	98.3±.26	13.7	2348.7	98.4±.19	58.7	90.5
50	25.3	2533.3	99.0±.22	14.3	2470.0	99.4±.1	23.7	96.1
100	2.3	2882.7	99.9±.038	0.3	2413.0	99.99±.023	12.7	97.9
0	2624.0	424.0	13.9±.59	2554.0	589.7	18.8±.48	615.3	-
L.S.D. 5%							78.2	

* Spray solution used in all trials - 1 quart 75% dinitro ortho secondary amyl phenol, 6.5 gallons kerosene, water to make 100 gallons.

These toxic effects were further tested in a series of 0.01 acre plots replicated 3 times in randomized blocks. The same treatments and methods of application were used as in the preceding tests. The results obtained are given in Table IV B and show further encouraging trends. All treatments resulted in highly significant reductions in red spider populations. At the end of 4 days there were no significant differences between the various rates although the degree of control appeared slightly lower in the 25 gallon plots. However, 8 weeks after treatment the percentage mite reduction in the 25, 50 and 100 gallon treatments was 48.0, 90.9 and 97.8 percent, respectively, as compared to the check.

Large Scale Tests.

Results of the preliminary trials were so promising that a series of field operation type plots was established to test the practicability of the method on a larger scale. DNOSAP sprays of the same concentration as those used in the preliminary trials just above were applied at 25, 50 and 100 gallons/A. rates by means of a John Bean Model 404T sprayer equipped with fan type nozzles and operating at 250 lbs. pressure per square inch. Plots were 0.25 acre in size and replicated 3 times in randomized blocks. Variations in gallonage were obtained by keeping the pump pressure constant and adjusting the rate of movement of the sprayer.

Observation of Table IV C indicates almost perfect control at the 100 gallon rate and a 99.4 percent reduction at 25 and 50 gallons after 5 days. Six weeks later there were still no significant differences between the various rates although there were evidences of a build up on the 25 gallon plots. Generally speaking the control obtained with the power sprayer was better than that obtained with hand equipment; this was particularly true at the 25 gallon rate.

Miscellaneous Tests.

Several interesting points of speculation were suggested by the high degree of red spider control obtained with the DNOSAP sprays. Chief among these were:

1) The possibility that much of the effectiveness may have been due to destruction of the strawberry plants at a time when the mites were comparatively inactive and unable to move to other food; 2) The importance of kerosene in the spray mixture; 3) The degree of control that might be expected with lower amounts of DNOSAP.

Small scale tests comparing the miticidal action of the several components of the standard spray mixture were conducted February 9, 1950. Methods of application, plot size and experimental technique were the same as those reported previously with the exception that 50 gallons of spray per acre was used.

The materials tested and results obtained are given in Table V. These data show that the deletion of kerosene from the standard spray had no immediate effect on mite control. Kerosene plus an emulsifying agent gave a significantly higher percentage kill than the check but was far below the DNOSAP treatments. However, DNOSAP and kerosene combined were far more phytotoxic to the strawberry foliage than either alone at the rates used in these trials.

Table V. Effects of Kerosene in DNOSAP Sprays on Red Spider Control.

Norfolk, Virginia. 2/9/50

Amount per 50 gallons spray*	Mean Number Mites per 33 (0.3 sq. in.) Samples 2/13/50		
	Alive	Dead	Percent Dead
1.5 percent emulsifier**	730.3	69.0	8.6
1.5 percent emulsifier + 3.25 gal. kerosene**	632.3	182.7	22.4
1 pint DNOSAP	5.0	790.7	99.4
1 pint DNOSAP + 3.25 gal. kerosene	2.3	767.7	99.7
Check	748.0	68.7	8.4
L.S.D. 5%			4.0

* Applied at rate of 50 gallons per acre.
** Based on kerosene content. Emulsifying agent "MULSOR" - Synthetic Chemicals, Inc.

In a later experiment DNOSAP and DNOSAP-kerosene sprays were compared at 0.125, 0.25, 0.5, and 1 pint toxicant per acre levels. All materials were applied at the rate of 50 gallons per acre to replicated 0.01 acre plots as before. In sprays containing kerosene, the standard rate of 3.25 gallons kerosene to 50 gallons of spray mixture was used in all cases.

Table VI shows that 0.125 and 0.25 pint of DNOSAP per acre did not give satisfactory mite control. Here again kerosene apparently had no immediate effect on the insecticidal action of the herbicide. Counts made one month after application in the 0.5 and 1 pint per acre plots failed to give significant differences but there were indications of a slight build-up in the DNOSAP treatments. At this time there was noticeably less foliage in the standard treatment. An index of the relative leaf area available was calculated by determining the average number of leaves and leaf size through examination of 100 plants from each treatment. Adjustment of mite populations to compensate for these differences indicated that the DNOSAP plots might eventually support more mites than those receiving the standard treatment. This increase appears to be correlated with the decreased phytotoxic action of the DNOSAP sprays as opposed to the standard DNOSAP-kerosene combination.

Table VI. Effects of Various Concentrations of DNOSAP and DNOSAP-kerosene Sprays on the Two Spotted Spider Mite. Norfolk, Va. 2/24/50

	Mean # Mites Alive per 1200 Examined				Mean # Mites per 50 (0.3 sq.in) Samples		Relative Total Population	
	2/28/50		3/3/50		3/23/50		3/23/50	
Amount per 50 Gallons Spray*	Number	% Red.	Alive	% Red.	Number	% Red.	Index	Number
1 pint DNOSAP	37.7	96.4	16.0	98.3	68.7	89.5	4.27	293.3
1 pint DNOSAP + kerosene**	30.3	97.1	13.0	98.6	31.3	95.2	1.0	31.3
0.5 pint DNOSAP	65.7	93.7	36.7	96.1	172.0	73.8	5.9	1014.8
0.5 pint DNOSAP + kerosene**	66.3	93.7	34.7	96.3	115.7	82.4	1.9	219.8
0.25 pint DNOSAP	215.7	79.4	202.0	79.7				
0.25 pint DNOSAP + kerosene**	235.0	77.6	203.3	79.5				
0.125 pint DNOSAP	380.3	63.8	355.7	62.4				
0.125 pint DNOSAP + kerosene**	400.7	61.8	353.0	62.7				
Check	1049.3	-	946.7	-	657.3	-	7.27	4778.6
L.S.D. 5%	30.1		51.7		84.6			

* Applied at rate of 50 gallons per acre.
** Kerosene content constant at 3.25 gallons per 50 gallons spray.

Discussion and Conclusions.

The toxicity of dinitro-compounds to insects has been known for some time but the writers were unable to find any previous reference concerning a combined insecticidal and herbicidal action on strawberries. Cooper and Nuttall (4) reported the marketing of dinitro insecticides in Germany as early as 1892. Kagy and Richardson (8) presented a rather extensive summary on the use of these compounds against a wide variety of insects. Boyce (1, 2) and Boyce et al. (3) demonstrated the effectiveness of dinitro-o-cyclohexylphenol in controlling several species of mites including the two spotted mite. Walker and Anderson in 1940 successfully used a dust containing dinitro-o-cyclohexylphenol in tests against the red spider on strawberries at this station (unpublished data). Despite the fact that controls as high as 95 percent have been obtained by the latter workers, a tendency to cause severe burning to strawberry leaves and blossoms at a temperature near 80° F. has limited the use of this material. Although 75 percent dinitro ortho secondary amyl phenol sprays are much more toxic to strawberry foliage than the DN dusts, plants so treated, despite complete defoliation at the time, later appeared more vigorous than untreated plants. Data presented by the senior author has demonstrated that applications of DNOSAP to strawberries during the dormant or near dormant period did not reduce the yield (Table I).

It is interesting to note that DNOSAP sprays, unlike most insecticides, do not seem to be appreciably affected by adverse weather conditions. For example, the large scale field tests were conducted at a temperature of 45° F. during a light drizzle which was followed by a 0.5 inch rain that night. Daily temperatures for the week following application of the low dosage DNOSAP and standard treatment series (Table VI) averaged 41, 31, 30, 43, 49, 33 and 32° F. respectively.

One of the chief problems in obtaining adequate red spider control with standard insecticides has been in getting a thorough coverage of the undersides of the strawberry leaves. In the case of older leaves lying flat to the ground, this is virtually impossible. Treating with DNOSAP-kerosene sprays kills these old leaves and makes it comparatively easy to cover the erect new growth which appears after dormancy is broken. However, according to observations in 1949 and 1950, there is a strong possibility that proper timing of the herbicidal spray may reduce red mite populations to a point where further treatment before harvest is unnecessary. A number of large commercial acreages of strawberries were treated with this material in the Norfolk area during 1949-50. In all cases red spider infestations were very light and failed to injure the crop whereas some adjacent areas were heavily damaged despite several applications of commercial insecticides.

The foregoing results and observations offer conclusive evidence that 75 percent dinitro ortho secondary amyl phenol in herbicidal concentrations effectively controlled the two spotted spider mite in Blakemore strawberries under weather conditions prevailing in the Norfolk area in the winter of 1949-50. It appears that the lower limit of satisfactory mite control lies somewhere around 0.5 pint of toxicant per acre. With improved methods of application it is believed that good initial control might be obtained with as little as 0.25 pint of DNOSAP per acre. Unfortunately, however, there is a tendency for the mites to build up more rapidly on the lower dosages. As indicated in the foregoing discussion, the amount of toxicant required to give weed control is dependent on the size of the weeds when sprayed. This is demonstrated in Table III where control of very small weeds was obtained with 25 gallons of the spray mixture indicated. Spider control figures on these trials are given in Table IV C. In general, results have indicated that rates of less than 25 gallons of this spray solution would not be effective as a weeding agent.

Summary

The effects of dinitro ortho secondary amyl phenol sprays on winter weeds and the two spotted spider mite in Blakemore strawberry plantings are reported here.

1. The dormant crop was found to be tolerant of single spray applications per season of concentrations of the chemical which would kill henbit and chickweed in the early stages of growth.

2. Single populations of these weeds were controlled. In cold winters when freezing or near-freezing weather prevailed much of the time, this was equivalent to all-winter control. Duration of control was limited during warm winters when successive populations of these weeds emerged.

3. A spray containing 75 percent dinitro ortho secondary amyl phenol gave excellent control of the two spotted spider mite on strawberries when applied at herbicidal concentrations. Under field conditions as little as 0.5 pint of toxicant per acre reduced mite populations 99.4 percent in six days. Commercial plantings were treated with DNOSAP and in no case did a serious mite problem develop.

4. Omission of kerosene from the standard mixture had no appreciable effect on the initial kill of red spiders but did give inferior residual action.

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Two Years Results on the Use of Certain Herbicides for Weed Control in Various Varieties of Strawberries[1]

Richard J. Aldrich and Richard E. Puffer

INTRODUCTION

Sodium 2,4-dichlorophenoxyethyl sulfate (Experimental Herbicide #1) showed considerable promise for selectively weeding strawberries in preliminary experiments conducted at the New Jersey Agricultural Experiment Station in 1949 (NEWCC Proceedings 1950). Although chemically very similar to 2,4-D, foliage applications of E.H. #1 did not appear to result in the pronounced formative effects characteristic of 2,4-D treatments in many plants. Apparently the material is toxic to germinating seeds, and as such it is effective as a herbicide when applied pre-emergence on the weeds.

As a consequence of these promising preliminary results, experimental work at the New Jersey Station with E.H. #1 in strawberries was considerably expanded in 1950. Field experiments were conducted on three different farms in the state and on the Horticulture Farm of the College of Agriculture.

Tests on Three Out-lying Farms

The following treatments were made in strawberries set out in the spring of 1950:

1. 3 pounds of E.H. #1 per acre in late June
2. 3 pounds of E.H. #1 per acre in late June and early August
3. Untreated.

Applications were made in 100 gallons of water per acre immediately following thorough cultivation and hand-hoeing. The strawberry variety was Sparkle in two tests and Redwing in the third. The experimental design was a randomized block with three replications. Weed counts were made at intervals following treatment to measure the degree and duration of control.

The effect of treatment on weed stands is given in Table I. One of the tests was cultivated before weed counts were made. In the two remaining tests, 3 pounds of E.H. #1 per acre provided better than 90% control of annual weed emergence for a period of thirty days. Weed counts made 51 days after treatment in the test on the Kirschman farm indicated that the effects of the chemical had decreased.

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[1]Acknowledgment is given to the Carbide and Carbon Chemical Corporation for their support of this project.

[2]Agent, USDA, BPIS&AE, Division of Weed Investigations and former Research Fellow, Horticulture Dept., Rutgers University, New Brunswick, N. J., respectively.

Table I. The effect of E.H. #1 at 3 lb./acre on weed stand in strawberries.

Plot Strawberries	Days After Spraying	Check Av. per sq. ft.		E.H. #1 3 lb./acre Av. per sq. ft.		% control	
		BL	G	BL	G	BL	G
Duryee*	23	4.6	1.2	.1	.1	98	92
Duryee	31	6.1	11.7	.2	.4	98	97
Kirschman**	23	5.2	6.1	0	.2	100	96
Kirschman	30	15.8	19.7	.4	.9	97	95
Kirschman	51	Used 15.8	19.7 for % control	3.3	3.9	79	80

* Main weeds were crabgrass, stinkweed, carpetweed and redroot

**Main weeds were crabgrass, stinkweed, carpetweed, pusley, lamb'squarters, and redroot

BL = Broad leaf weeds G = Grass weeds

Observations of the strawberry plants following treatment showed no evidence of injury. Yields will be taken in 1951.

Test in Sparkle variety on Horticulture Farm

The following treatments were made in strawberries set out in the spring of 1950:

1. 1 lb. E.H. #1 per acre June 26
2. 3 lbs. " " " "
3. 6 " " " " "
4. 3 " " " " " and July 29
5. 6 " " " " " and July 29
6. 1 lb. 2,4-D amine per acre June 26
7. 14 lbs. E.H. #2 per acre June 26
8. Check.

Applications were made in 100 gallons of water per acre immediately following thorough cultivation and hand-hoeing. The experimental design was a randomized block with three replications.

The effect of the various treatments on weed stands is shown in Table II. With the exception of E.H. #2 all treatments provided effective emergence control of annual weeds.

There were no apparent injurious effects of E.H. #1 treatments to the strawberry plants. Plants treated with 2,4-D exhibited formative effects characteristic of 2,4-D for a short period following treatment, but appeared normal on October 1, 1950. Many plants treated with E.H. #2 were dying on October 1

Table II. The effect of chemical treatments on weed control in strawberries on the Horticulture Farm, College of Agriculture, Rutgers University.

Treatment	Sparkle* Variety** — First Spraying[1]: Weeds per sq. ft. BL	Weeds per sq. ft. G	% control BL	% control G	Second Spraying[2]: Weeds per sq. ft. BL	Weeds per sq. ft. G	% control BL	% control G	First Spraying[3]: Weeds per sq. ft. BL	Weeds per sq. ft. G	% control BL	% control G	Second Spraying[4]: Weeds per sq. ft. BL	Weeds per sq. ft. G	% control BL	% control G
Check	6.8	4.8	---	---	9.0	--			8.9	6.7			18.3	3.7	--	--
E.H. #1																
1 lb./A	1.0	.4	85	91												
3 lb./A	.2	.5	97	90	1.0	2.0	89	--	.3	.4	97	94	5.0	.4	73	89
6 lb./A	.0	.0	100	100	1.0	0.0	89	--								
E.H. #2																
14 lb./A	5.8	2.4	15	50												
2,4-D																
1 lb./A	.4	.3	94	94					.4	.6	95	91				

* Predominant weeds: lamb'squarters, redroot pigweed, pusley, and crabgrass
** Predominant weeds: redroot pigweed, pusley, and crabgrass

[1]Counted 24 days after spraying
2 " 40 " " "
3 " 23 " " "
4 " 41 " " "

with runner plants appearing to be most severely effected. Prior to October 1 E.H. #2 treated plants showed no evidence of injury.

Yield data will be taken on these plots in 1951.

Variety test, Horticulture Farm

Red Crop, Pathfinder, Redwing, Midland, Dorsett, and Fairfax varieties set out in April were given the following treatments:

1. 3 lb. E.H. #1 per acre June 26 and July 28
2. 1 lb. 2,4-D amine June 26
3. Check

Applications were made in 100 gallons of water per acre immediately following thorough cultivation and hand-hoeing. The experimental design was a split-plot with three replications.

Weed control obtained with the treatments is given in table II.

There were no apparent injurious effects of E.H. #1 treatment to any variety. Although many 2,4-D treated plants showed typical 2,4-D formative effects following treatment, the abnormalities did not persist.

Yield data will be taken on these plots in 1951.

SUMMARY

1. 3 pounds of E.H. #1 per acre applied pre-emergence on weeds provided better than 90% control of annual weed emergence for four weeks in four different tests.

2. A total of 12 pounds of E.H. #1 per acre did not result in any visible injury to Sparkle strawberries.

3. Typical 2,4-D formative effects following a one pound per acre application of the 2,4-D amine were outgrown.

4. A 14 pound per acre application of E.H. #2 resulted in the death of many plants early in the fall.

5. There was no indication of differetial varietal response to E.H. #1 treatment.

EFFECT OF CERTAIN HERBICIDES ON THE GROWTH OF FIRST YEAR STRAWBERRY PLANTS

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A herbicide that is to be generally accepted for weed control in strawberries must meet two requirements. It must control weeds effectively, and it must give a minimum of injury to the strawberry plants. 2,4-D has been tested on strawberries in the Northeast for several years with varying degrees of success. Danielson (2) reported that 1.4 lb. of sodium or amine salt of 2,4-D applied in June and July gave good control of weeds without injury to the Blakemore variety. Gilbert (3) observed no visible injury to Redwing from 1 lb. amine 2,4-D applied in July, but 2 and 4 lbs. of isopropyl ester applied in March considerably retarded the growth of Blakemore. Gilbert and Wolf (4) reported injury to strawberry plants from 1 lb. amine 2,4-D applied either once or twice in the season. Some varieties were injured more than others. Occasional experiences of serious injury probably explains why 2,4-D has not been generally recommended for strawberries.

Preliminary reports have suggested that E. H. 1 (sodium 2,4-Dichlorophenoxy ethyl sulfate) may be of value for weed control in strawberries (4). IPC has been suggested for the control of chickweed in strawberries (1).

An experiment was undertaken in the spring of 1950 to study the value of 2,4-D, IPC and E. H. 1 for strawberry weed control in southwest Virginia. This paper is a report on the influence of the herbicides on the first year's growth of three varieties of strawberries.

Method

Plants of Blakemore, Premier and Catskill varieties were set on May 17, 1950. This rather late date of planting, coupled with the somewhat heavy soil used for the planting, resulted in a below average rate of growth for all plots.

The treatment plots consisted of single rows of the three varieties 15.5 feet long with one guard plant at each end. There were 7 plants of each variety in each plot. The plants were set 2 feet apart in rows which were 3.5 feet apart. The varieties and plots were randomized and replicated 3 times.

The rates of materials[1] and schedule of applications were as follows:

1. 2,4-D (amine salt) 1.5 lb. acid equiv. per acre, applied June 16.
2. 2,4-D (amine salt) 1.5 lb., plus IPC (wettable powder) 10 lb. per acre, applied June 16.
3. E. H. 1, 4 lb. per acre, applied June 16 and August 11.

A check plot in each replicate was hand weeded and received no chemical treatment.

The chemicals were applied as aqueous sprays at the rate of 50 gallons per acre. Many of the plants had begun to send out runners by June 16, the time of the first chemical sprays.

The areas between the rows were given normal cultivation. The rows were hand weeded as often as necessary to prevent undue weed competition. All weeds were removed from the plots just prior to chemical treatments.

Results

Stunting of the strawberry plants in the 2,4-D plots could be seen as early as July 10. The plants which had received the E. H. 1 spray, however, appeared to be as vigorous as the untreated plots.

On August 24, a count was made of the number of runner plants that had rooted. This count was made 10 weeks after the original application of all chemicals had been made and 2 weeks after the second application of E. H. 1. The number of runner plants that had rooted by August 24 seemed to be a reasonable measure of the vigor of the planting. There were occasional missing parent plants at the time of the count. An analysis of variance, however, showed no significant difference in the number of parent plants present between varieties, treatments, or for the variety x treatment interaction. The average number of rooted runner plants per parent plant for each of the varieties and treatments are presented in table 1.

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[1]Grateful acknowledgement is given Dow Chemical Company, John Powell and Company, and Carbide and Carbon Chemicals for providing the materials for this work.

Table 1. Average number of rooted runner plants per parent plant for three varieties and four treatments. Runner plants were counted on August 24.

Treatments	Blakemore	Premier	Catskill	Treatment Average
	Varieties*			
2,4-D[1]	6.8	2.2	3.0	4.0
2,4-D + IPC[2]	7.2	4.2	4.8	5.4
E. H. #1[3]	12.3	5.9	8.4	8.8
Hand Weeded Check	11.9	6.8	8.9	9.2
Least significant difference @ 5%				2.5

[1]Amine salt 2,4-D, 1.5 lb. acid equiv. per acre, applied June 16.

[2]2,4-D, 1.5 lb., plus wettable IPC, 10 lb. per acre, applied June 16.

[3]Sodium 2,4-Dichlorophenoxy ethylene sulfate, 4 lb. per acre, applied June 16 and August 11.

* The variety X treatment interaction was not significant.

The data in table 1 show a marked reduction in the number of rooted runner plants as a result of the 2,4-D sprays. There was no indication that IPC applied as a mixture with 2,4-D gave any additional injury to the strawberry plants. The E. H. 1 treatment did not significantly reduce the number of rooted runner plants as compared with the hand weeded checks.

It could be seen on close examination that the 2,4-D treatments stunted the parent plants, reduced runner plant development, and appeared to inhibit the rooting of many runner plants. E. H. 1 appeared to prevent rooting of some of the runner plants, but the data in table 1 indicate that the effect was not marked. Based on general observations of the plots, the plants treated with E. H. 1 were slightly less vigorous than plants in the check plots.

It is possible that the reduction of runner plants by 2,4-D on vigorous varieties such as Blakemore may not be serious, especially in regions of a long growing season. The seriousness of the damage caused by the herbicides on three varieties will be more accurately measured by the yields produced in 1951.

No attempt was made to obtain an accurate measure of weed control. Crab grass, purslane and wild potato were the most prevalent weeds. Plots which received chemical treatments did not require hand weeding for about 6 weeks after treatment. The check plots required attention about every 2 to 4 weeks, depending on weather conditions. There were no marked differences between the three chemical treatments in effectiveness of weed control. The residual action of 2,4-D was perhaps slightly greater than E. H. 1.

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RECENT DEVELOPMENTS IN CRANBERRY WEED CONTROL

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Recent work in Cape Cod cranberry weed research has centered on three groups of weed chemicals--2,4-D, Stoddard Solvent, and copper sulphate solutions--all of which are now in commercial use on a limited scale.

2,4-D

It is quite impossible to use esters of 2,4-D with safety on or about cranberry bogs. The iso-propanolamine salt seems best suited for weed control both on and around the bogs, and, even with this salt, great caution must be exercised to keep the chemical from direct contact with the cranberry vines. For this reason, only those weeds which attain a stature higher than the cranberry can well be treated. There are, however, a large number that do this, including loosestrife (Lysimachia), 3-square grass (Scirpus), hardhack or steeple-bush, meadow sweet, roses, bayberries, sweet fern, sweet gale, leather leaf, sheep laurel, sometimes poison ivy, chokeberry, ferns, and others. If the weed population is sparse or occasional, individual hand wiping with a wet cloth glove worn outside a rubber glove is best. In denser stands of weeds, the best mode of attack seems to be that of carrying a sheet of cloth or burlap stretched on a wooden framework and saturated with a 20% solution of the 2,4-D salt across the bog above the tops of the cranberry vines but low enough to brush the leafy tips of the weeds. In this way, a small amount of very concentrated 2,4-D is applied to each of the tall growing weeds and is accomplished in very rapid fashion. Some of the frames have been made a rod long and 18" to 36" wide, and they are carried by two men--one at each end. In this manner, an acre can be treated almost as quickly as it takes a man to walk a linear distance of 160 rods, or 1/2 mile. From time to time, the stretched cloth must be rewet. The frequency of rewetting is determined by the relative humidity of the air and the density of the weed growth being treated. Tests with a dry finger tip seem ample for determining whether or not the cloth is still moist enough to deposit 2,4-D on the weed foliage.

This form of weed treatment has been in use for only two years, and results are still somewhat variable. However, the increasing popularity of the device among cranberry growers is evidence enough that many weeds are killed or greatly retarded in this way, sufficiently so to induce the growers to use it. More specific data will be available in another year on the value of this method in cranberry weed control.

Stoddard Solvent

During the last two years, considerable experimental work has been done with Stoddard Solvents of varying aromatic content, and this has been supplemented by considerable commercial-scale work with Stoddard in contrast to kerosene applications. From all of this, the following results have been determined:

1. That sprayings of Stoddard Solvents varying from 200 to 1000 gallons per acre may be applied to cranberry vines in the spring before May 10 and after harvesting in October and November without apparent injury to cranberry vines or their prospective crops.

2. That cranberry vines are damaged and their crop prospects ruined by sprays of Stoddard Solvent at 200 gallons per acre or more, after the opening of the terminal buds in May and until the crop is matured in September. It should be understood that growing season applications do not kill the vines; recovery is apparently complete after eight weeks.

3. That variations in the aromatic content of Stoddard Solvents make no difference either in the herbicidal value of the oil or in the toxic effect to cranberry vines.

4. That weeds belonging to the following genera are far more sensitive to Stoddard sprays than to kerosene: Juncus, Spergularia, Aster, Solidago, Smilax, Rubus, Rosa, Lysimachia, and Osmunda.

Copper Sulphate Solutions

During the last two years, it has been found that sprays of copper sulphate solutions, 25 pounds in 100 gallons of water and applied at 400 gallons per acre in August, either control or kill various species of Bidens, Panicum verrucosum, fireweed (Erechtites hieracifolia), nut grass (Cyperus dentatus), and hair-cap moss (Polytrichum commune). These sprays do not injure cranberry vines but may produce tiny specks on a small percentage of the berries. The speckling of the fruit is less severe when the spraying is done late in August and is most severe from sprayings made early in the month when the fruit is small and green. In any case, it is the appearance of the fruit only that is damaged and not its quality. These sprays are relatively inexpensive and control a variety of annual weeds that are apt to grow intermixed in the same areas of bogs. The greatest drawback to their general use is their corrosiveness to power spraying equipment.

Further Developments in Gladiolus Weed Control

By

Robert F. Carlson, James E. Moulton and Paul R. Krone[1]

In 1947 Krone and Hamner (3) reported on the use of 2, 4-D and various contact herbicides for the control of weeds in plantings of Gladioli. Since their aim, in part, was to eliminate or destroy most of the weed seeds in the upper soil horizon that range of concentrations used by them was rather high, from 2½ pounds per acre to more than five times this amount. They obtained satisfactory control of weeds without apparent injury to the Gladioli by planting the corms three weeks after the application of 2, 4-D. Since that report 2, 4-D has been used in various ways on a considerable acreage and by a number of commercial growers.

From the practical standpoint treatments following planting are more desirable than those before this time. In the tests reported here, the materials were applied after the corms were planted but before either the weeds or corms emerged. It has been found that germinating seeds are more easily killed than the growing seedlings and consequently lower concentrations of the herbicide will give satisfactory results (1). The primary aim in this work was to test several new commercial compounds at minimum herbididal rates in an effort to obtain maximum control of weeds with the least effect on the production of corms and flowers.

Materials and Methods

A little less than one acre of land was planted to Gladiolus corms and cormels in 1950. The soil varied from a heavy dark organic loam to a lighter clay sandy loam. Approximately one half of this area was planted with size 6 corms and the other half with cormels both of the Gardenia variety set in rows four feet apart. Each treatment consisted of a strip of row 50 feet long and two feet wide, and each treatment was replicated four times.

The materials used on the corms and rates per acre were as follows: 2, 4-D at 1 and 2 pounds; EH 1 (Sodium 2, 4-Dichlorophenyl "Cellusolve" sulfate) at 2, 3 and 4 pounds; EH 2 (Dichloral Urea) at 3, 6, and 9 pounds; "Premerge" (Alkanolamine Salt of Dinitro-o-Sec-Butylphenol) at 3.0, 4.5 and 6.0 pounds; and "TAT G-W" (2, 4-D, 2.54% and Phenyl mercuric acetate 7.50%) at ½, 3/4 and 1 pound (based on 2, 4-D). On the cormels the above and also the following materials were used: IPC (Isopropyl N-phenyl carbamate) at 5, 10 and 15 pounds; EH 5722 at 1, 2 and 3 pounds; and Aero Cyanate (potassium cyanate 91%) at 12.5, 25.0 and 37.5 pounds. All materials were applied in aqueous solution with a knapsack sprayer at the rate of 50 gallons per acre. The rate per acre was based on the area sprayed constituting about one-half of the actual bulb acreage.

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The corms and cormels were planted June 15 and the herbicides applied June 21. Weed counts of all treatments were taken July 12 by counting the number of weeds per square foot and four counts made per treatment. All weeds were removed by hand and hoeing from all plots on August 7. The time required for this operation was recorded and computed as man-hours per acre for each treatment.

Many weeds were present in the check plots, and some of the most common weeds were: Rough pigweed (Amaranthus retroflexus L.), Lambsquarters (Chenopodium album L.), common ragweed (Ambrosia elatior L.) Purslane (Portulaca oleracea L.) Crabgrass (Digitaria sanguinalis L. Scop.) and Downy-bromegrass (Bromus tectorum L.).

Table I. Per Cent Weed Control In Gladiolus Corms and Cormels Under Different Rates of Several Herbicides and Subsequent Yield, Based on Average of Four Replications; Man-hours of Hoeing per Acre During the Season.

Materials	Pounds Per Acre	Corms			Cormels		
		Per Cent		Man-hours Hoeing	Per Cent		Man-hours Hoeing
		Weed Control	Yield		Weed Control	Yield	
2,4-D	1.0	68	97	11.0	53	100	10.0
2,4-D	2.0	83	93	7.2	82	88	8.3
EH 1	2.0	67	88	15.8	74	51	11.7
EH 1	3.0	70	90	15.0	80	69	7.5
EH 1	4.0	89	71	8.3	92	69	4.2
EH 2	3.0	17	98	26.7	47	56	23.3
EH 2	6.0	40	99	14.1	62	100	15.0
EH 2	9.0	52	94	13.3	65	48	13.3
"Premerge"	3.0	44	90	25.0	59	66	15.0
"Premerge"	4.5	52	87	24.0	65	98	12.5
"Premerge"	6.0	62	91	18.3	82	100	10.8
"TAT G-W"	0.5	59	100	19.1	68	100	12.5
"TAT G-W"	0.75	67	100	17.5	88	100	9.2
"TAT G-W"	1.00	82	100	10.8	92	100	6.7
IPC	5.0	-	-	-	39	85	20.8
IPC	10.0	-	-	-	41	95	20.0
IPC	15.0	-	-	-	65	80	15.8
EH 5722	1.0	-	-	-	0	100	49.2
EH 5722	2.0	-	-	-	0	77	40.0
EH 5722	3.0	-	-	-	12	100	37.5
Aero Cyanate	12.5	-	-	-	0	95	40.0
Aero Cyanate	25.0	-	-	-	0	100	44.2
Aero Cyanate	37.5	-	-	-	0	100	46.7
Check	0.0	-	100	-	-	100	45.8

Results

Weed Control in the Corms: At the rates used in this experiment, 2, 4-D, EH 1 and "TAT G-W" gave the most uniform and consistant control of weeds (Fig. 1). All these materials gave 60 per cent or more control. The "TAT G-W" also controlled the annual grasses (Crabgrass and Downy-brome-grass) present in this planting. The new material EH 1 compared favorably to 2, 4-D in effectiveness as a herbicide.

When used at 1 and 2 pounds per acre, 2, 4-D gave 68 and 83 per cent control of weeds respectively. Since the material was applied 6 days after the planting of the bulbs many of the weed seeds were germinating and some were emerging providing favorable conditions for maximum kill with 2, 4-D. The EH 1 applied at the rates of 2, 3 and 4 pounds per acre gave 67, 70 and 89 per cent weed control respectively. The timing of the application is very important with EH 1 since this material is primarily a seed toxicant (2). "TAT G-W" was used at the rate of 1/2, 3/4 and 1 pound per acre based on the 2, 4-D content in the formulation, and the control of weeds was 59, 67 and 82 per cent respectively (Table I).

The material Premerge satisfactorily controlled the weeds at the 6 pound rate, however, 3.0 and 4.5 pounds per acre evidently were not sufficient to control the weeds under these conditions. The control was 44, 52 and 62 per cent at 3.0, 4.5 and 6.0 pounds per acre respectively. Since all the materials were calculated on the basis of the area sprayed (row treatment) the rates used are actually low amounting to 1.5, 2.3 and 3.0 pounds per acre when the total acreage of the field is considered.

Weed Control in the Cormels: The material "TAT G-W" at 1/2, 3/4 and 1 pound per acre applied 6 days after planting controlled 68, 88 and 92 per cent of the weeds respectively. Most of the grasses present were controlled at these rates which is an important factor in Gladiolus weed control. Yields of bulbs were not reduced with this material at any of the levels used. The material EH 1 used at 2, 3 and 4 pounds per acre gave comparable control of the weeds without any evident reduction in bulb yield or visible injury to the foliage. Since EH 1 is not injurious to plant foliage it could be applied following the harrowing and later, if needed, following row-cultivation. Two pounds per acre of 2, 4-D gave similar control of weeds in cormels as that reported above for corms. The one-pound rate controlled 53 per cent of the weeds (Table I). "Premerge" used at 3.0, 4.5 and 6.0 pounds per acre eliminated 59, 65 and 82 per cent of the weeds respectively. This shows an increase over the response obtained with the same material in corms. It is believed that by increasing the 6-pound rate to 8 pounds, control would be still better since that amount of "premerge" would cover 2 acres of corms or cormels by the row spraying system in actual field production.

The materials EH 2 and IPC at the rates used were not as effective in controlling the weeds as were the other herbicides. EH 2 gave 47, 62 and 65 per cent control at 3, 6 and 9 pounds per acre respectively, and IPC at

5, 10 and 15 pounds controlled 39, 41 and 65 per cent of the weeds. Perhaps at higher levels or under different conditions these materials might be more effective.

The time spent in hoeing was reduced greatly with some treatments. Only one-fourth man-hours per acre was required on areas where 2 pounds of 2, 4-D and 4 pounds of EH 1 had been applied. Other treatments reduced labor anywhere from 1/4 to 3/4 of that required to eliminate the weeds from untreated areas (Table I).

Summary

About one-half acre of land was planted to corms and another half acre to cormels in spring of 1950. Five herbicides (2, 4-D, EH 1, EH 2, "TAT G-W", and Premerge) at three levels each were applied as row-treatments to the corms six days following planting. On the cormels these five and three others (IPC, Aero Cyanate, and EH 5722) were applied in a similar manner. Weed counts and hoeing time were recorded during the season and yield data recorded when harvested October 4.

The herbicides "Premerge", 2, 4-D, "TAT G-W" and EH 1 satisfactorily controlled more than 65 per cent of the weeds in the corms, whereas EH 2 and IPC controlled about 50 per cent. Eighty per cent (and above) of the weeds were eliminated during the season on the plots where the following materials were used at the rates indicated; one pound of "TAT G-W", 4 pounds of EH 1 and 2 pounds of 2, 4-D.

Similar results were obtained with the herbicides used on cormels. Eighty per cent (and above) of the weeds were eliminated on the plots where the following materials were used at the rates indicated; three-fourths pounds "TAT G-W", one pound "TAT G-W", 3 pounds EH 1, 4 pounds EH 1, 2 pounds 2, 4-D and 6 pounds of "Premerge".

No appreciable reduction in yield was encountered with any of the treatments. Since corm and cormel yield is often variable, any small difference due to treatment is difficult to detect.

Labor was reduced greatly under some treatments.

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WEED CONTROL STUDIES WITH EXPERIMENTAL HERBICIDE 1 AT SEABROOK FARMS, BRIDGETON, N. J.[1]

Thomas P. Finn and L. J. King

Introduction

Experimental Herbicide 1 (Sodium 2,4-dichlorophenoxyethyl sulfate) has been widely tested for weed control use on many crops. Gilbert and Wolf (3) and Carlson (1) have reported its use on strawberries. Nohl and Odland (6) in Pennsylvania have reported tests with this chemical on spinach, peas and asparagus. Tests with this herbicide on lima beans applied 3 and 5 days after seeding have been reported by Rahn and Ogle (7) in Delaware. Pre-emergence and post-emergence experiments on Katahdin potatoes are described by Cobb (2). The 1949 tests on lima beans at Seabrook Farms have also been reported (5).

Detailed laboratory and greenhouse tests on this chemical have been dealt with previously (4). At that time the unique properties of this new herbicide were described. Spray or dust applications of Experimental Herbicide 1 to the foliage of sensitive plants result in little or no epinastic responses and very slight, if any, formative effects. This is a highly significant fact when it is realized that none of the usual drift hazards involved in the use of 2,4-D are encountered with this material. Experimental Herbicide 1 is a non-volatile, free-flowing powder and offers no formulation difficulties since it is freely soluble in water.

All the herbicidal applications were made with a Kupfer power sprayer mounted on the front end of a Farmall tractor. This sprayer had a trailer-type spray tank (capacity 125 gal.) and a 20 foot boom adjusted to spray 12" above the ground with Teejet-type nozzles spaced 9" apart. The chemical sprays were applied as water solutions at the rate of 40 gal. per acre except as otherwise noted. All necessary data pertaining to the date of planting, spraying, cultivating, weed counting and harvesting are given in the text preceeding each test.

Weed Control Studies on a Three Year Old Asparagus Planting

Materials and Methods

Experimental Herbicide 1, (Sodium 2,4-dichlorophenoxyethyl sulfate) and compound 5476, (calcium 2,4-dichlorophenoxyethyl sulfate) were tested for the control of weeds throughout the growing season in an established asparagus planting. Both herbicides were first applied to two rows of asparagus 570 feet long, when the spears were starting to emerge on April 27, 1950, in an aqueous spray at the rate of 2 pounds per acre. This 2 pound per acre rate was again applied on May 24 (second application) and again of June 17 (third application); compound 5476 was not applied on May 24. Prior to each application the plots were cultivated but not hilled so that the soil surface of the asparagus row remained undisturbed. The

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control plot was also cultivated in the same manner and weeds developing in the row were not destroyed. The fourth and final application of 2 pounds per acre was made on July 8 after the cutting season when the field had been disked and a fertilizer application had been made. Weed counts were made by counting the number of broadleaf and grass weeds within a six inch square over 48 randomized sections of the plot. Values expressed as per cent of the control. The asparagus spears were cut regularly, starting on May 14 and continued through June 28, 1950. The number of cuttings taken during this period totaled thirty-seven. Twenty-three of these cuttings were graded, and the average per cent of No. 1, culls and butts are given in the table.

On July 25, 1950, asparagus samples that had been collected from the Weed Control Experiment were submitted to a taste panel. The six panel members were asked to rate the samples according to good or normal flavor, fair or dull flavor, and off flavor. The samples had been prepared by running them through the regular commercial processing procedure. The samples had been collected from the first, second and fifth cuttings following each herbicidal application.

Results and Discussion

Excellent weed control was maintained with both herbicides for approximately three weeks following each application. However, weeds were controlled after the fourth application for approximately six weeks. The weed species controlled were velvet-leaf (Abutilon Theophrasti), lambs quarters (Chenopodium sp.) and crabgrass (Digitaria spp.). Because weeds were effectively controlled by the herbicides in the asparagus row, it was not necessary when cultivating to hill the rows. Frequent hilling adds additional soil that the asparagus spears must push through before cutting. Such hilling often makes it necessary to disk the field level in the latter part of the cutting season thereby cutting down on the yield. The asparagus spears cut throughout the growing season developed normally and did not show any chemical or physiological responses from this application. Yields as indicated in Table 2 were not affected by the herbicides. The difference between replications however, is attributed to the variation of plant vigor in each row. Stand counts taken during the fern stage revealed a high percentage of poor or missing plants in rows that had a yield of less than 100 pounds. The high percentage of culls and butts in both treated and control plots is due to the fact that all spears regardless of size or shape were harvested (Table 2). The results of a Taste Panel on the processed asparagus rated both herbicides about equal to the control in regard to flavor.

Table 1. Weed Count Data in Asparagus Plots.

Chemical	Rate	Date of Treatment	Date of Weed Counts	Av. number weeds per sq. ft. Broadleaved	Av. number weeds per sq. ft. Grass	Per cent of the control Broadleaved	Per cent of the control Grass
				1st application			
E.H. 1	2 lbs/A	4/27/50	5/10/50	0.5	0.2	99.9	98.0
E.H. 1*	2 lbs/A	"	"	0.2	0.3	99.8	96.8
5476*	2 lbs/A	"	"	0.4	0.2	99.6	98.0
Control	0	"	"	90.4	8.0	0	0
				2nd application			
E.H. 1	2 lbs/A	5/24/50	6/15/50	1.1	0.7	98.4	97.1
E.H. 1	2 lbs/A	"	"	1.0	0.9	98.6	96.5
Control	0	"	"	68.3	24.1	0	0
				3rd application			
E.H. 1	2 lbs/A	6/17/50	6/30/50	2.3	1.7	93.9	94.5
E.H. 1	2 lbs/A	"	"	3.3	2.8	91.0	90.6
5476	2 lbs/A	"	"	2.3	1.8	93.8	93.9
Control	0	"	"	36.2	30.0	0	0
				4th application			
E.H. 1	2 lbs/A	7/8/50	8/17/50	1.0	0.8	92.7	95.8
E.H. 1	2 lbs/A	"	"	0.8	1.2	93.9	94.1
5476	2 lbs/A	"	"	0.8	2.0	93.9	89.8
Control	0	"	"	13.7	19.5	0	0

*Experimental Herbicide 1 (Sodium 2,4-dichlorophenoxyethyl sulfate) and 5476 (Calcium 2,4-dichlorophenoxyethyl sulfate) were sprayed in a 25 gal./A rate of water at this time. All other applications were sprayed at a 40 gal./A rate of water.

Table 2. Yield and Grading Records of Asparagus from Experimental Plots.

Chemical	Rate	Yield Data: Total of 37 cuttings of replicate rows in lbs. Repl. 1	Repl. 2	Average	Grading Record: Av. per cent of 23 gradings No. 1	culls	butts
E.H. 1*	6 lbs/A (3 applications)	85.0	112.8	197.8	57.2	21.9	20.9
E.H. 1	6 lbs/A (3 applications)	136.5	72.8	209.3	54.3	21.9	23.8
5476**	4 lbs/A (2 applications)	108.8	93.0	201.8	54.7	23.1	22.2
Control		72.8	101.5	173.8	55.7	20.7	23.6

*E.H. 1 (Sodium 2,4-dichlorophenoxyethyl sulfate)
**5476 (Calcium 2,4-dichlorophenoxyethyl sulfate)

Weed Control Studies on Sweet and Field Corn Sprayed at Three Different Time Intervals After Planting.

Materials and Methods

Experimental Herbicide 1 (Sodium 2,4-dichlorophenoxyethyl sulfate) and the triethanolamine salt of 2,4-dichlorophenoxy acetic acid were tested on both sweet and field corn to determine the best time of application in regard to crop safety and maximum weed control.

Both the sweet corn (Var. Golden Cross) and field corn (Var. U.S. #13) were planted on July 28, 1950. Both herbicides were then applied to single corn plots each consisting of 6 rows of corn 200 feet long at three different time intervals after planting. The first set of plots were treated on the day of planting with Experimental Herbicide 1 at 1 and 2 lbs./acre and the 2,4-D amine salt at 1 lb./acre. The second set of plots were treated four days after planting when the corn was just emerging from the ground with Experimental Herbicide 1 at 2 and 3 lbs./acre and 2,4-D amine salt at 1 lb./acre; the last set of plots were treated with Experimental Herbicide 1 at 2 and 3 lbs./acre and the 2,4-D amine salt at ½, 1 lb./acre seven days after planting when the sweet corn was approximately 3-4 inches tall and field corn 4-6 inches tall. Rainfall of 0.12 inches was recorded six days following planting and 0.63 inches was recorded seven days following planting which was the same day after the post-emergence application. No appreciable amount of weeds were visible on the day of planting or four days later when the first and second set of plots were treated. By the seventh day, however, when the third set of plots were treated, weed seedlings had germinated and were in the seedling stage. Weed counts were taken on August 25, 1950, by counting the number of broadleaf and grass weeds within a six inch square over twenty-four randomized sections of the plot. Values are given in the number of weeds per square foot and expressed as per cent of the Control.

Results and Discussion

The best control of both broadleaf and grass weed species was obtained when the chemical applications were made four days after planting (Tables 3 and 4). The broadleaf weeds, mostly lambsquarters (Chenopodium sp.) were effectively controlled by both herbicides at the three different time intervals. Crabgrass (Digitaria spp.), however, was best controlled when incipient germination occurred over a period of several days before the herbicides were applied. Twenty per cent more crabgrass was controlled when both herbicides were delayed until four days after planting. It is also noted that Experimental Herbicide 1 gave satisfactory control of crabgrass when applied seven days after planting whereas 2,4-D amine at ½ and 1 lb. of acid per acre did not control crabgrass effectively when applied at this time. A survey of the corn plants did not reveal any injury or physiological effects except in the plot treated with 2,4-D amine at 1 lb./acre seven days after planting. The corn in this plot showed the typical onion leaf effect.

Table 3. Weed Count Data in the Sweet Corn Plots.*

Chemical	Rate in lbs./acre	Date of Application	Average no. weeds/sq. ft. Broadleaved Weeds	Average no. weeds/sq. ft. Grass Weeds	Per cent of control Broadleaved Weeds	Per cent of control Grass Weeds
E.H. 1	1	7/28/50	3.7	2.5	99.6	66.2
E.H. 1	2	"	1.3	2.7	99.5	63.5
2,4-D amine salt**	1	"	3.2	2.5	98.7	66.2
E.H. 1	2	8/1/50	0.7	1.0	99.7	86.5
E.H. 1	3	"	0.3	1.0	99.9	86.5
2,4-D amine salt**	1	"	1.2	1.5	99.5	79.8
E.H. 1	2	8/4/50	0.8	1.0	99.7	86.5
E.H. 1	3	"	1.7	1.3	99.3	82.4
2,4-D amine salt **	½	"	3.5	3.8	98.6	48.7
2,4-D amine salt **	1	"	3.8	2.8	98.5	62.2
Control	0		25.6	7.4	0	0

*Sweet corn (Var. Golden Cross) planted July 28, 1950. Weed counts taken August 25, 1950.
**2,4-D amine salt applied at lbs. of acid equivalent per acre.

Table 4. Weed Count Data in the Field Corn Plots.*

Chemical	Rate in lbs./acre	Date of Application	Average no. weeds/sq. ft. Broadleaved Weeds	Average no. weeds/sq. ft. Grass Weeds	Per cent of control Broadleaved Weeds	Per cent of control Grass Weeds
E.H. 1	1	7/28/50	7.5	1.8	63.4	81.6
E.H. 1	2	"	2.2	1.3	89.3	86.7
2,4-D amine salt**	1	"	4.3	4.3	79.5	56.1
E.H. 1	2	8/1/50	1.2	1.5	94.2	84.7
E.H. 1	3	"	0.5	0.8	97.6	91.8
2,4-D amine salt**	1	"	0.3	0.5	98.5	94.9
E.H. 1	2	8/4/50	0.2	0.3	99.0	96.9
E.H. 1	3	"	0.3	0.5	98.5	94.9
2,4-D amine salt**	½	"	3.2	2.5	84.4	71.4
2,4-D amine salt**	1	"	2.5	2.3	87.8	76.5
Control	0		20.5	9.6	0	0

*Field corn (Var. U.S. #13) planted July 28, 1950. Weed counts taken August 25, 1950.
**Same as above.

Summary

1. Experimental Herbicide 1 when sprayed on an asparagus planting before, during and after the cutting season controlled weeds effectively without affecting quality or yield of the spears.

2. In plantings of sweet and field corn the best control of weeds was obtained when germination of weeds occurred over a period of several days before Experimental Herbicide 1 and the amine salt of 2,4-D were applied. The 2,4-D amine salt, applied post-emergence at 1 lb./acre of acid produced the typical onion leaf effect on the sweet corn. Experimental Herbicide 1 at 3 lbs./acre did not produce such an effect.

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COMPARATIVE HERBICIDAL EFFECTIVENESS OF CERTAIN ALKYL AND GLYCOL ESTERS OF 2,4-D AND 2,4,5-T.

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INTRODUCTION

Early in the development of 2,4-D and its derivatives it became evident that the alkyl esters were more effective herbicides than the acids or salts. This seemed to be particularly true under adverse conditions, when the vegetation was hard and tough or in a slow-growing state rather than soft and in a fast-growing or succulent condition. Therefore, the alkyl esters of both 2,4-D and 2,4,5-T came into wide use. Experiments comparing the activities of various alkyl esters of 2,4-D and 2,4,5-T such as the methyl, ethyl, isopropyl, butyl, etc., usually showed insignificant differences.

Several years ago after surveying the field it was theorized that certain esters of 2,4-D and 2,4,5-T might be found that would have a lower vapor pressure than the lower alkyl esters of 2,4-D and 2,4,5-T so that less would excape from the treated plants to the atmosphere. In addition it was thought that other esters might have better penetration or translocation properties. With these objectives in mind, over one hundred different esters were made and tested.

MATERIALS AND METHODS

Both laboratory and field techniques were used in this study. The laboratory methods used were the tomato dip technique and a modified single drop bean test. Briefly, the tomato technique involves the application of the chemical in a water solution or emulsion to young plants. The treated plants are then grown in a greenhouse and observations made. This method is described in detail in another paper (2). The single drop bean test has also been described elsewhere (1) (3) but two slight modifications will be briefly mentioned here. A micrometer-driven syringe is used to deliver a 0.006 ml. drop. A single drop, usually of a 1000 ppm. solution, (7), is applied to each bean plant. Ten cranberry bean plants were used for each replicate. The drop is applied while the primary leaves are still expanding and the apical bud is present with little or no stem visible between it and the second node.

The field work involved the usual field practices. Both small and large plots were used. Pertinent data regarding field application methods will be mentioned with each experiment.

Some of the experimental work was done with the dipropylene glycol butyl ether ester of 2,4-D and 2,4,5-T. Most of the experimental data was obtained using a mixture of the mono, di, and tri propylene glycol butyl ether esters of 2,4-D or the same esters of 2,4,5-T. Hereafter in this paper this mixture of esters will be called the polypropylene glycol butyl ether esters of 2,4-D or 2,4,5-T as the case may be.

LABORATORY TESTS

After a large number of esters of 2,4-D and 2,4,5-T had been tested it became evident that certain glycol ether esters of 2,4-D and 2,4,5-T were less volatile than the corresponding isopropyl esters. In addition, screening tests using tomato plants indicated that certain glycol ether esters were more active herbicidally than the corresponding isopropyl esters. Therefore, evaluation tests using the single drop bean technique were run. The results of 5 tests are given in Table 1.

TABLE 1 - HERBICIDAL EFFECTIVENESS OF CERTAIN GLYCOL ETHER ESTERS OF 2,4-D AND 2,4,5-T AS COMPARED WITH THE ISOPROPYL ESTERS OF 2,4-D AND 2,4,5-T.

Compound	Plant growth expressed as percent of control					
	Test 1 3 repl.	Test 2 4 repl.	Test 3 4 repl.	Test 4 4 repl.	Test 5 4 repl.	Average
Untreated control	100	100	100	100	100	100
isopropyl ester 2,4-D	72		85	89	82	82
Polypropylene glycol butyl ether ester 2,4-D	48		86	79	69	70
isopropyl ester 2,4,5-T	14	16		56	51	34
polypropylene glycol butyl ether ester 2,4,5-T	12	9		29	25	19

Since the laboratory tests showed that these glycol ether esters had greater herbicidal activity and were less volatile than the isopropyl esters, it was decided to test these materials in the field.

Field Tests with Herbaceous Species

Tests were conducted with several herbaceous species for the purpose of comparing the herbicidal effectiveness of the more promising glycol ether esters of 2,4-D with the isopropyl ester. In no instance did the dipropylene glycol butyl ether ester or the polypropylene glycol butyl ether esters appear inferior to the isopropyl ester as herbicides. In several instances they induced greater plant responses and were more herbicidal in their effect than the isopropyl ester. Some of the experiments in which the differences were clear cut are described.

Dandelion (Taraxacum officinale)

Several 2,4-D esters were applied at 3/4 lb. acid equivalent in 50 gallons of water per acre using a garden-tractor mounted rig fitted with a speedometer for accurate speed control. Following the treatment which was made in early August, conditions were hot and dry for about one month during which there was little growth of the dandelions. Active growth resumed following September rains. Final counts of dead and recovered plants were made in early October. The isopropyl ester and several other esters under test gave kills of from 80 to 90%. On the plot treated with the dipropylene glycol butyl ether ester 95 percent of the dandelions were killed.

The following year three separate comparisons applied on different dates during the spring were made on dandelion-infested turf at rates of 1/2 and 1 pound per acre of 2,4-D acid equivalent. The three separate tests were rated for relative herbicidal effectiveness several weeks after application. At 1 pound per acre the kill was practically complete from all derivatives used. At 1/2 pound per acre differences were evident in each test. The mean rating for the three tests was 63 for the isopropyl ester and 83 for the polypropylene glycol butyl ether esters.

Leafy Spurge (Euphorbia esula)

In two of the four sets of plots on this weed no outstanding differences between the esters of 2,4-D were evident. In the other two, the results of which are described below, marked differences were observed.

One-hundredth acre plots were laid out in mid-June in a solid stand of leafy spurge and treated with several esters of 2,4-D at 1 pound acid equivalent per acre. The materials were applied in 100 gallons of water per acre with a knapsack sprayer. Several weeks after treatment only an occasional sprout had emerged in the plot treated with the dipropylene glycol butyl ether ester. Regrowth in the isopropyl ester treated plot was estimated at 60 percent of the control plot.

In August a similar test was made on leafy spurge which had been mowed earlier in the season and allowed to regrow. In this test the 2,4-D esters were applied at 2 and 3 pounds acid equivalent per acre. Inspection after growth had stopped in the fall revealed considerably less regrowth on plots sprayed with the dipropylene glycol butyl ether ester than those sprayed with the isopropyl ester.

Golden Rod (*Solidago* sp), Curly Dock (*Rumex crispus*) and Wild Carrot (*Daucus carota*)

The same plot technique was used with these species so results will be reported together in Table 2. The isopropyl and the polypropylene glycol butyl ether esters were applied to one thousandth acre plots laid out on uniform stands of each species. Treatments were made at 2,4,6 and 8 ounces acid equivalent per acre. The vegetation was young and in an active stage of growth. The treatments and rates were randomized within the experimental area.

Five persons who knew nothing of the plot layout rated the plots about 10 days after application. The rating system used gave the plot showing the greatest degree of response a value of 100 and the unsprayed control plot a value of 0. Other plots were rated according to the relative degree of response from 0 to 100. The ratings are summarized in Table 2.

TABLE 2 - MEAN RATING FOR 4 RATES OF 2 ESTERS OF 2,4-D ON 3 SPECIES WITH TEST CONTROL ASSIGNED A VALUE OF 100. EACH MEAN REPRESENTS 5 INDIVIDUAL RATINGS BY QUALIFIED OBSERVERS UNFAMILIAR WITH THE PLOT LAYOUT

2,4-D ester	Ounces per acre	Golden rod	Curly dock	Wild carrot	Mean for 3 species	Grand mean	Expressed as percent
Isopropyl	2	14	20	12	15		
	4	38	46	28	37		
	6	60	76	62	66	59	71
	8	54	72	62	61		
polypropylene glycol butyl ether	2	14	26	14	18		
	4	42	68	76	61		
	6	62	88	72	72	83	100
	8	100	100	94	98		

It will be noted from Table 2 that the polypropylene glycol butyl ether esters were superior to the isopropyl ester at all rates on all three species. The differences between the mean of all rates and all species was 71 percent for the isopropyl ester compared with the polypropylene glycol butyl ether esters expressed as 100 percent. This difference appears to be of practical significance.

The observations on which these figures were based were made relatively soon after treatment and it is not implied that the same differences would have been found at a later date after the treated plants had either died or recovered.

Field Tests with Woody Plants

The field work on woody plant control is divided into two parts: first, foliage applications; second, dormant treatments. The dormant treatments here mentioned are concerned solely with basal or stump treatments and not as an overall plant spray. Experiments by several workers have indicated that such basal treatments, knee high or about 1 1/2', are as effective as overall sprays. This method has therefore been the subject of considerable experimentation because of its possible economic applications.

White Ash (*Fraxinus americana*)

Plots extending 100 ft. along a roadside were sprayed in the spring with the isopropyl ester of 2,4-D, the isopropyl ester of 2,4,5-T, the polypropylene glycol butyl ether esters of 2,4-D and the same esters of 2,4,5-T. Applications were made with an orchard type gun. A concentration of 2 1/2 lbs. acid equivalent in 100 gallons of water was used for all materials. This brush was 3 to 5 ft. high and was in the first year of regrowth.

In view of the fact that ash is generally regarded as one of the more resistant species of woody plants, the results of this test were interesting. Plants sprayed with the isopropyl ester of 2,4-D showed a slight twisting and occasionally a kill of the terminal growth but were not materially effected. In contrast those sprayed with the polypropylene glycol butyl ether esters of 2,4-D showed severe epinasty in the terminal areas and proliferation along the entire length of the stem. The comparable ester of 2,4,5-T gave essentially the same results and final kill in both plots where these esters were used approached 90 per-cent. Control with the lower esters did not exceed 10 per-cent.

A second test applied a month later gave essentially the same results.

Maple (*Acer saccharinum*)

Sprouts growing from maple stumps cut during the previous winter were sprayed July 15. Applications in this instance were made with a knapsack sprayer and the concentration used was 2 1/2 lbs. acid equivalent per 100 gallons of the above esters. The sprouts at the time of application averaged 30 inches high and the plants were in an active stage of growth.

In this particular test the most striking difference noted was in the superiority of the esters of 2,4,5-T over the esters of 2,4-D. In general both esters of 2,4-D were ineffective and the net result from treatment with these esters was a kill of the terminal bud and development of a small amount of stem proliferation in that area.

Plants treated with the isopropyl ester of 2,4,5-T showed an immediate response which was primarily a burning of the leaves with no great amount of epinasty. On the other hand plants treated with the polypropylene glycol butyl ether esters of 2,4,5-T did not show this degree of rapid burn but did, however, show more systemic reaction as indicated by the epinastic responses of the leaves and shoots. This ester gave complete control of all clumps sprayed with no regrowth the following year while 30 per cent of the plants sprayed with the isopropyl ester of 2,4,5-T produced sprouts again.

Buckbrush (*Symphoricarpos occidentalis*)

One-hundredth acre plots of buckbrush located at Grand Forks, North Dakota were sprayed in mid-June using the isopropyl ester of 2,4-D in comparison with the polypropylene glycol butyl ether esters of 2,4-D at a rate of one pound acid equivalent per acre.

Inspection of these plots in August showed that the higher molecular weight ester had killed 95 per-cent of the buckbrush. Plots treated with the isopropyl ester showed only slight defoliation and discoloration. This experiment has been repeated several times and in each instance the polypropylene glycol butyl ether esters have been more extensive translocated and have given a higher percentage of kill.

Oak (*Quercus spp.*)

In February, the polypropylene glycol butyl ether esters of 2,4,5-T and the isopropyl ester of 2,4,5-T were applied as basal treatments to dormant oak sprouts using fuel oil as a carrier. Concentrations of 4, 8, 16, 24, and 32 pounds of acid per 100 gallons of spray were compared. The results of this test presented in Table 3 indicate that the polypropylene glycol butyl ether esters were superior in preventing re-sprouting and regrowth.

TABLE 3 - PER CENT KILL OF OAK SPROUTS SPRAYED DURING DORMANT PERIOD WITH ALKYL AND GLYCOL ETHER ESTERS OF 2,4,5-T.

	Acid equiv. in lbs./100 gallons of fuel oil				
Ester of 2,4,5-T	4	8	16	24	32
Isopropyl	13.5	18.5	15.0	29.5	87.4
polypropylene glycol butyl ether	14.7	15.2	68.4	80.6	89.0

Large Scale Field Trials

Woody plant control tests conducted on a semi-commercial basis in Michigan, Missouri, New England, New York, Oklahoma, and Pennsylvania all showed a very definite trend in favor of the polypropylene glycol butyl ether esters. This trend is particularly evident on resistant species and when plants are in a resistant state of growth.

Conclusions

1. Laboratory tests using a biological assay method have shown that the polypropylene glycol butyl ether esters of 2,4-D and 2,4,5-T have a much lower vapor pressure, that is, are much less volatile than the corresponding isopropyl esters.

2. In laboratory studies the polypropylene glycol butyl ether esters of 2,4-D and the corresponding esters of 2,4,5-T have proved to be more herbicidally active than the isopropyl esters.

3. Certain field experiments on herbaceous and woody species indicate that these glycol ether esters of 2,4-D and 2,4,5-T are superior to the alkyl esters of 2,4-D and 2,4,5-T under many conditions.

4. While the experiments show that the polypropylene glycol butyl ether esters of 2,4-D and 2,4,5-T have been superior on some species of plants, they may not show this superiority on all species under all conditions particularly those favorable for good kill. However, in no instance have they been inferior to the isopropyl esters.

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CHEMICAL WEED CONTROL IN ASPARAGUS SEEDLINGS ON A COMMERCIAL SCALE IN 1950

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The problem of weed control in asparagus seedlings is serious due to their slow germination and slow growth for two or three months after emergence. For this reason asparagus growers are reluctant to grow their own crowns in Delaware. The following demonstration, therefore, was set up to test the effectiveness of a pre-emergence application of a contact herbicide.

Two fields, one of eight and the other of four acres, were treated a week apart. Details are given only on the former, herein, since the results obtained were similar. The soil was a Sassafras sandy loam highly infested with seeds of such common weeds as smartweed, pigweed, lamb's quarters, purslane, carpet weed, morning glory, crab grass, and others. Rainfall was abundant and well distributed for two months subsequent to seeding the asparagus, making for rapid germination and growth of weeds. Both fields were seeded to the Mary Washington variety immediately after seedbed preparation. After seeding the first field on May 4, the soil was not cultivated for six weeks and then not close to the row until June 24, seven and a half weeks after seeding. The herbicide was applied on May 20, sixteen days after seeding, on a cool, cloudy day when the soil was quite moist. At this time, the tips of the germinating asparagus seedlings were approximately 1/4-inch from the soil surface. There was already an abundance of weeds present, the tallest of which were two inches high. The contact herbicide used was a mixture consisting of 9.4 per cent pentachlorophenol in a highly aromatic oil. It was applied at the rate of five gallons per acre in 45 gallons of water. A tractor-mounted sprayer equipped with Monarch No. 59 fan-type nozzles was used in which the pressure was maintained at 40 pounds per square inch.

On May 24, it was observed that practically all weeds were killed except a few patches of nutgrass, which was affected very little. The asparagus was then 1/4-inch above ground. On June 6, two and a half weeks after the herbicide was applied, weed counts were made. The asparagus seedlings were then four inches high. On the treated area, there was on a representative 3-square foot area, an average of five very small weeds per square foot, while on the untreated area, a small strip through the center of the field, there was an average of 185 weeds per square foot, some of which were six inches high. Soil was not thrown to the row by cultivation until June 24, five weeks after treatment. The asparagus seedlings were then six inches high and there was an occasional weed over an inch tall showing in the row - crab grass, carpet weed, and morning glory in particular. For the remainder of the season, only two light hoeings in addition to tractor cultivation was necessary. No injury to the asparagus seedlings resulting from the use of the herbicide was observed.

The success of this demonstration indicates that it is possible to get good weed control in asparagus seedlings by pre-emergence spraying with a contact herbicide. Further tests, however, should be conducted to confirm these results.

PRELIMINARY RESULTS ON THE USE OF OILS AND OTHER CHEMICALS AS STEM SPRAYS FOR WEED CONTROL IN ONIONS

Joe Antognini*

This work was begun in an effort to find a chemical which would be very toxic to the weeds commonly found in onions grown on muck soil and would not be injurious to the onions if applied so that the chemical came in contact with the stem of the onion only. During seasons when onions remain upright until bulbing was well under way such a chemical should be of great value to growers who had not been able to keep weed growth well under control by the use of cyanamid and cyanate.

Materials and Methods

A stem sprayer for experimental plots was designed by the author and used for the application of all chemicals used (Figure #1). A similar setup was designed for use on a commercial scale but was not used in the experiments reported below (Figure #2). The rig used in this year's work was fitted with #650067 Tee-Jet fan tips so that when it was moved along at normal walking speed the rate of delivery was 35 gallons per acre for the area actually covered which was a three-inch strip on each side of the onion row. The apparatus in which the spray solution was placed was the apparatus developed by S. M. Raleigh and R.E. Patterson (1) using a five-pound carbon dioxide cylinder as a source of pressure.

The chemicals used were:
- -a- NIX - 15#/A - 35 gal. of solution/A.
- -b- Na Cyanamid - 15#/A - 35 gal. of solution /A.
- -c- Shell #130 - 8 gal./A - 35 gal. of solution/A.
- -d- Gasolene -35 gallons per acre.
- -e- Esso #45 -35 gallons per acre.
- -f- Varsol #2 - 35 gallons per acre.
- -g- Agronyl A - 35 gallons per acre.
- -h- 4 % Cyanate plus sticker - 35 gallons /A.

For all observational tests, except the first one, each chemical was applied to 15 feet of row. In the first test only Esso #45, Varsol #2 and Agronyl A were used on onions which were just showing the 4th true leaf. Each of these three chemicals was applied to one row five hundred feet long. In all tests the spray was directed below the growing point region.

In the larger experiments in which Agronyl A was applied eight replications were used in a four by four block. Each replicate was 6 rows wide and 15 feet long. In one of these experiments the spray was directed below the growing point region and in the other the spray hit as much as 1 inch above the growing point region due to the type of cultivation practiced.

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Figure #1

DIAGRAM OF STEM SPRAYER FOR USE ON SMALL PLOTS

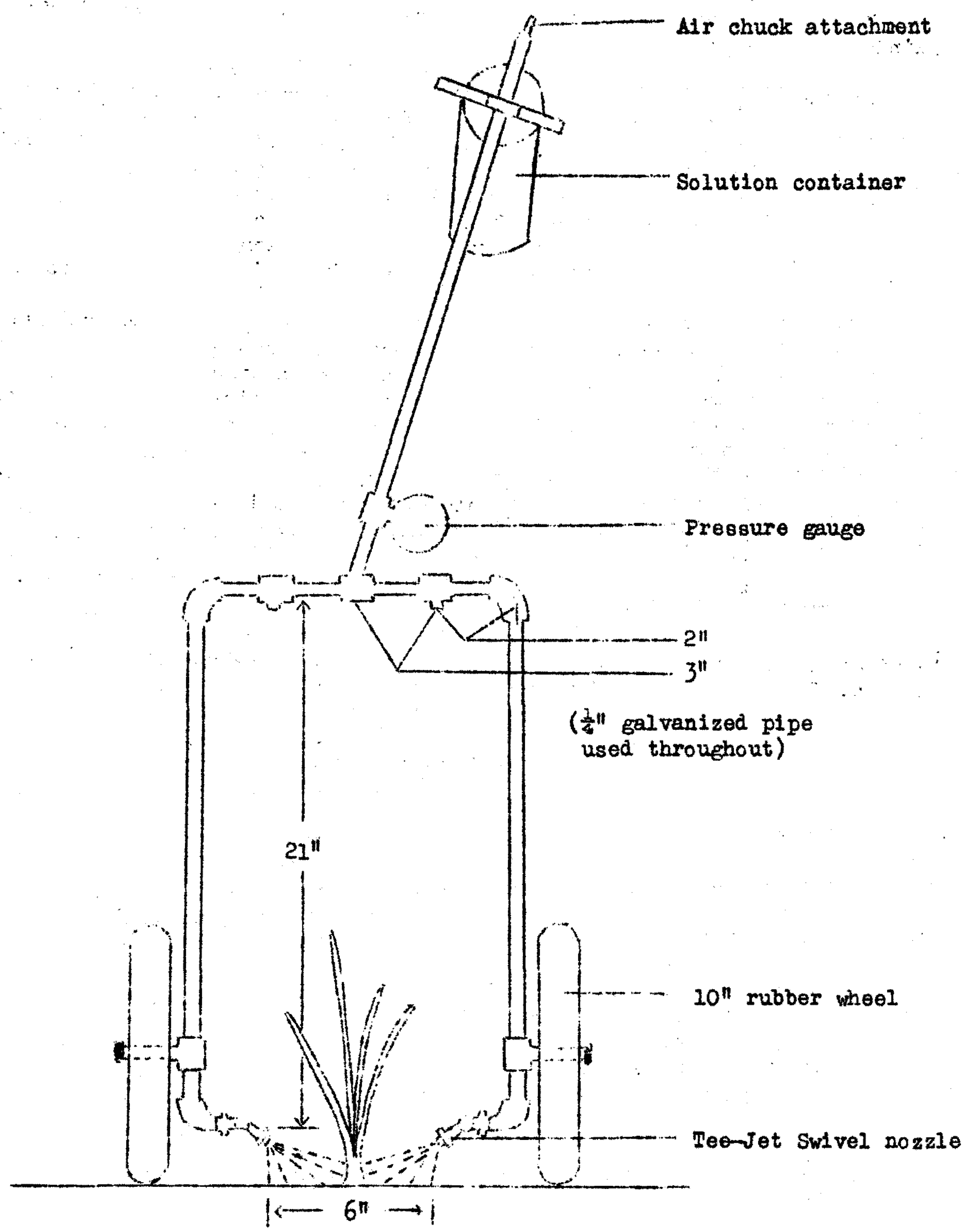
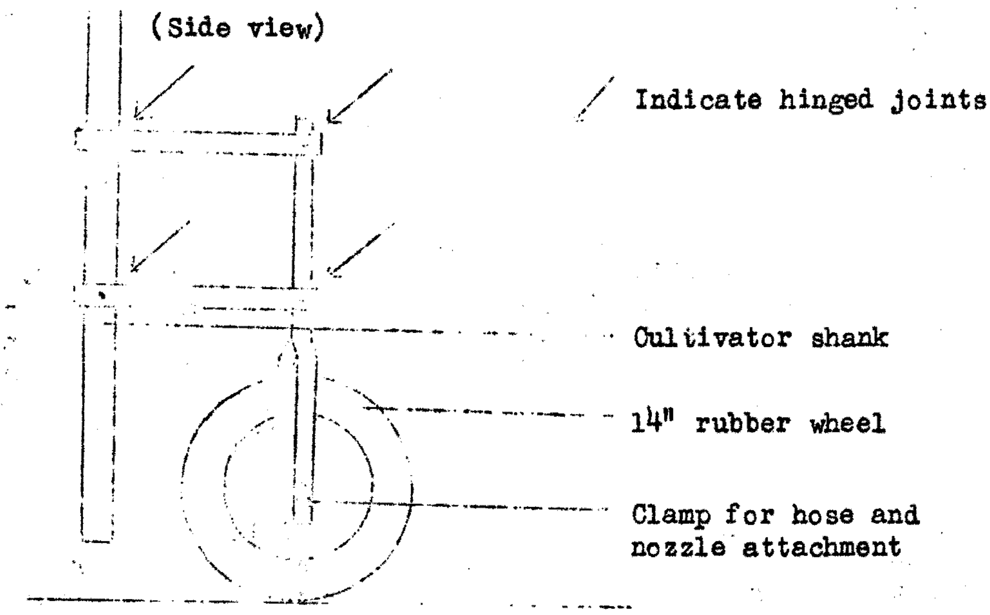
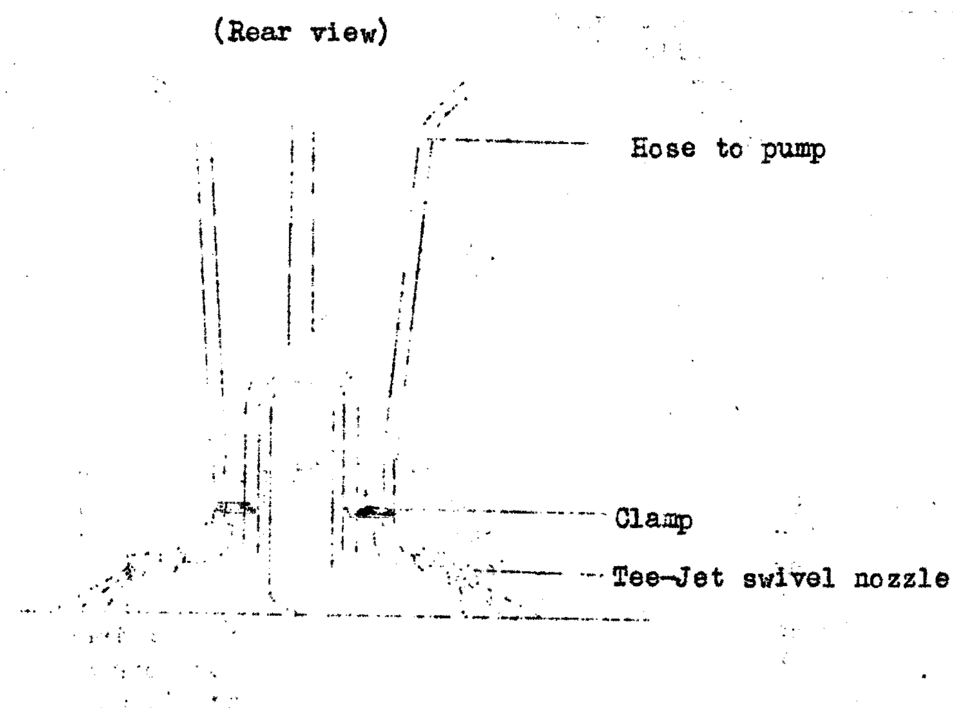


Figure #2

DIAGRAM OF STEM SPRAYER FOR USE ON A COMMERCIAL SCALE IN MUCK GROWN ONIONS





The weed counts in each of these plots were determined from two strips each of which was 3 inches wide on each side of the row and 2 feet long. Yield data were obtained by harvesting four rows 13 feet long in the center of each plot.

Additional details concerning the various experiments are given under "Results".

Results

Observational tests

The first of these tests using only Esso #45, Varsol #2 and Agronyl A was applied to onions which were just showing the 4th true leaf. Purslane (Portulaca oleracea), the only weed present, possessed stems 4 to 6 inches long at the time of application. All three chemicals resulted in a 100 per cent weed kill but Esso #45 and Varsol #2 severely injured all onions. Agronyl A injured an occasional onion which was smaller than average. As a result of these first observations, Agronyl A was used in the larger experiments reported below.

All of the chemicals listed above were used in three succeeding observational tests with the size of the onions varying from the 5th true leaf just emerging to the time when it was no longer feasible to go through the onions. In all of these tests Purslane was the predominant weed and in all cases the stems were at least 6 inches long.

Sodium cyanamid, Shell #130 and Aero Cyanate exhibited only moderate toxicity to Purslane while NIX, Esso #45, Varsol #2, gasolene and Agronyl A resulted in a 100 per cent kill of the Purslane in all cases. The only injury to the onions was the burning off of the lower leaf by all chemicals. There are two possible explanations as to the reason why Esso #45 and Varsol #2 severely injured the onions in the first test and not in the later ones. The first is that the onions were smaller and secondly that the temperature was higher at that time than it was in any of the later tests. In all of the above tests Agronyl A exhibited a definite residual effect. No weed counts were made but the effect was readily visible for as long as three weeks after application.

Agronyl A - Experiment #1

The experiment consisted of 16 plots, eight of which were used as checks and Agronyl A applied to the remaining eight at the rate of 35 gallons per acre. Each plot consisted of six rows fifteen feet long from which four rows thirteen feet long were harvested for yield data. At the time of application on June 24, the 5th leaf of the onions was two and one-half inches long and the barnyard grass (Echinochloa muricata) was four to six inches tall. All check plots were hand weeded at the time the oil plots were applied. Observations and counts were made only on barnyard grass since it was the predominating weed present.

The type of cultivation practiced in the field where this experiment was located consisted of deep cultivation between the rows and at the same time throwing muck into the onion row in an effort to control the weeds therein. As a result of this method of cultivation the above ground portion of the onion plants below the growing point region was only 3/4 to 1 inch in contrast to 2 to 2½ inches where level cultivation was practiced. In spraying, therefore, it was impossible to keep the spray entirely below the growing point region.

Eleven days after application the onions in the treated plots were 2 to 3 inches shorter than in the check plots. Accompanying the reduction in size the tips of the leaves were slightly curled. Although the injury to the tips of the leaves was soon outgrown the reduction in size persisted throughout the remainder of the growing season. At harvest time it was noted that in the Agronyl plots there were many one to two foot sections of row in which the bulbs were quite small.

Grass counts were made on July 21, 28 days after application. There was significantly less grass in the Agronyl plots as can be seen in Table 1. Coupled with the reduction in number of weeds was a considerable reduction in the size of weeds. The barnyard grass in the checks was approximately four feet high with the panicles possessing well developed seed whereas in the Agronyl plots the grass was only two feet high and flowering had not yet occurred.

Table 1.

Treatment	Number of barnyard grass plants per square foot Average of two square feet per plot								Mean
Agronyl A	0.5	1.0	0.0	1.0	1.5	2.0	0.5	1.5	1.00
Check	3.5	5.5	5.0	2.5	3.5	5.0	4.5	4.0	4.19

t = 2.56 Odds = 99:1

The onions were harvested and yield data taken on August 21, 59 days after application. From Table 2 below it can be seen that the yield was significantly reduced in the treated plots. This reduction in yield is believed due primarily to the fact that the oil was not kept off the growing point area as discussed above. In comparing this experiment with Experiment #2 it would indicate that the onions could not tolerate the oil when applied at this early stage of growth. The observations made on the observational tests would, however, strongly indicate that this is not the case.

Table 2.

Treatment	Total yield per plot in bushels per acre								Mean
Agronyl A	834	861	849	825	765	879	667	779	807
Check	945	959	1009	1159	934	1001	946	941	987

t = 5.00 Odds = 9999:1

Agronyl A - Experiment #2

The layout of this experiment was identical to that described for Experiment #1. The same variety of onions, Early Yellow Globe, was used. In this experiment, however, the onions were larger, the predominant weed was purslane instead of barnyard grass and level cultivation had been practiced rather than ridging. It was possible to keep the spray entirely away from the growing point region because of the level cultivation. At the time of application on July 14 the 6th leaf of the onions was 5 inches long and the purslane was in the 4th and 6th leaf stage. All check plots were hand weeded at the time the oil plots were sprayed.

Weed counts were made on August 10, 28 days after application, and again on August 25, 43 days after application. It can readily be seen from Table 3 that after 28 and 43 days there were significantly less weeds in the treated plots. As in Experiment #1 there was also a reduction in the size of the weeds showing that the oil either delayed germination or in some way injured the small seedlings before they emerged since no seedlings were visible in the oil plots until 23 days after application. The purslane plants in the check plots had stems 8 to 10 inches long 43 days after application whereas in the Agronyl plots the largest plants possessed only 8 leaves.

Table 3.

Treatment	Number of purslane plants per square foot Average of two square feet per plot								Mean
Agronyl A 28 days	5.5	3.5	4.0	5.5	5.0	4.5	3.0	2.0	4.12
Check 28 days	13.5	16.0	10.5	15.5	14.5	12.5	11.0	16.5	13.75
Agronyl A 43 days	6.5	6.5	5.5	10.0	6.5	5.0	8.0	9.0	7.12
Check 43 days	18.5	14.5	15.5	15.5	17.5	13.0	18.0	14.5	15.87

For 28 days after - t = 10.54 Odds = 9999:1
For 43 days after - t = 9.54 Odds = 9999:1

The onions were harvested and yield data taken on August 25, 43 days after application. The results are given below in Table 4. From the table it is seen that there was no significant difference in yield betwæn the Agronyl plots and the check plots.

Table 4.

Treatment	Total yield per plot in bushels per acre								Mean
Agronyl A	802	839	944	924	884	927	874	937	891
Check	921	1010	932	871	841	909	930	953	921

t = 1.17 Odds = 7:1

Summary

Results of this investigation indicate that oils and other chemicals can be used successfully as stem spray for the control of weeds in onions, particularly from the middle of the season up until it is no longer feasible to go through the onions. If this type of weed control is to be used level cultivation must be practiced, thereby permitting application of the materials in such a manner that none of it reaches the growing point region of the onions.

Agronyl A, Esso #45, Varsol #2, gasolene and NIX were highly effective in controlling the weeds commonly found in muck grown onions. Agronyl A exhibited a marked residual effect in addition to being quite toxic to the weeds present at the time of application. Agronyl A would therefore serve a twofold purpose when used as an herbicide in onions. The first being that it effectively controls the current season's growth of weeds. Secondly because of its residual effect, it would greatly aid in accomplishing the ultimate goal of relatively weed-free muck. By inhibiting the growth of weeds for two to three weeks after the last spraying, it is possible that the onions could be harvested and the field disked before few if any weeds produce viable seed.

Although the above results are promising it should be kept in mind that they are only preliminary results and that considerable work needs to be done with these and other chemicals on a commercial basis as well as on an experimental basis. For late applications it will have to be determined whether or not chemicals applied as stem sprays affect storage quality of the onions in any way.

Literature Cited

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Chemical Weed Control in Corn, Cabbage, Tomato, and Other Crop Plants

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Chemical weeding of vegetables and corn has not proved entirely satisfactory either because the period of weed control is not long enough or because of adverse effects of the herbicide on crop plants. Some success in weeding row crops has resulted from the use of controlled directional spraying, with or without the use of shielding equipment. In this case the edge of the spray is directed toward the bases of the plants under conditions which do not permit a toxic dose of the herbicide to contact the foliage on the upper, most sensitive part of the plant. At certain stages of growth such crops as corn, snap beans, onion, carrot, and cabbage can be weeded between the rows and partially or completely weeded in the row by proper directional spraying with herbicides which have little or no residual effect on the crop. There is still a need for more effective herbicides for controlling grasses and broad-leaved weeds without causing injury to crop plants.

Results of greenhouse tests showed that a number of compounds, most of which have not been reported as herbicides, killed tomato and other test plants and weeds when the chemical was applied as a foliage spray at concentrations of 1 to 3 per cent. Two of the most effective of these compounds, monochloroacetic ($CH_2ClCOOH$) and undecylenic [$CH_2{=}CH(CH_2)_8COOH$] acids, were used in the field for weeding vegetable crops and sweet corn. In sweet corn tests, 2,4-D was used alone and in combination with monochloroacetic and undecylenic acids. The present report gives the results of the herbicidal tests in the greenhouse and the results of field tests in which monochloroacetic and undecylenic acids were used to weed vegetable crops and sweet corn. Other uses of these two acids, as for example, defoliation, blossom thinning, inhibition of buds, and their selective action against certain plants, are described by the authors elsewhere in these Proceedings (Killing of Leaves and Defoliation of Plants by Chemical Means).

Materials and Methods

Monochloroacetic (ClA) and undecylenic (UN) acids and their triethanolamine salts were the principal herbicides used in most experiments. The salts of each, as well as the acid of ClA, were water soluble. The UN acid not being water soluble was applied as an oil emulsion spray. The water soluble polyethylene glycol ester of UN was used in some of the tests. Spray solutions of the herbicide were applied in most cases at a concentration of 1 per cent, using 0.25 per cent Nekal NS as a wetting agent. Overall and between-row sprays were applied to most crops at various stages of growth with respect to weeds and the crop plants.

A Hudson Junior 2-gal. sprayer, fitted with one Spraying Systems Teejet #8015 nozzle, was used in applying the sprays. Rates of delivery sufficient to wet the foliage thoroughly, varied with the size of the weeds from approximately 125 gal. per acre on the smaller weeds to 300 gal. per acre on the larger ones.

Test plots varied from 100 to 300 sq. ft. Crop plants included sweet corn, cabbage, potato, tomato, onion, carrot, and snap bean. The main weeds found in the plots were purslane, Chenopodium album, crabgrass, galinsoga, chickweed, smartweed, ragweed, mustard, Amaranthus sp., oxalis, and white clover. Sedges and barnyard grass (Echinochloa sp.) were also spersely scattered throughout the plots.

Greenhouse Tests

In greenhouse tests tomato plants were killed when the plants were sprayed with 1 per cent solutions of the following compounds: chloroacetic, bromoacetic, iodoacetic, α-chloropropionic, mucochloric, α,β-dichloroacrylic, furylacrylic, and undecylenic acids; sodium chloroacetate, chloroacetamide, methyl undecylenate, isobutyl undecylenamide, n-undecyl alcohol, and polyethylene glycol "300" undecylenate. The following compounds were effective when used at a concentration of 3.2 per cent: ethyl chloroacetate, dichloroacetic acid, cyanoacetic acid, β-chloropropionic acid, α-chlorocrotonic acid, mucic acid, barbituric acid, azelaic acid, lauric acid, α,β,β-trichlorobutyric acid, n-undecylenic aldehyde, and n-undecylic aldehyde.

Many of the compounds listed above, particularly those effective at 1 per cent, killed one or more species of weeds. ClA and UN were especially effective for killing young weed seedlings in from less than 1 to 24 hours without causing noticeable residual effects in the soil. These two herbicides exhibited a selective action against several species of pot-grown herbaceous and woody ornamental and crop plants. When gladioli and corn were 12 inches or higher, no injury resulted from treatment with a 1 per cent solution of ClA or UN when the sprays were applied to the basal 4 inches of the plants even though weed seedlings were completely eradicated. The following pot-grown plants were also weeded effectively by controlled directional spraying with a 1 per cent solution of ClA or UN: Euonymus radicans var. vegeta, orchid, Ilex sp., peach, loblolly pine, gardenia, Taxus sp., carnation, and rose.

Field Tests

Pre-emergence treatments. Since ClA and UN are contact herbicides which exhibit no noticeable residual effect in the soil, their application as pre-emergence sprays was arranged so that a substantial number of weeds had germinated before emergence of the crop (onion, carrot, snap bean, and potato). Under these conditions ClA and UN killed the emerged weeds and, as judged by the lasting effect of the treatment, presumably many weed seeds that had germinated at or near the surface of the soil were also killed. Thus, the crop emerged through a practically weed-free soil surface which remained nearly weed-free for about 30 days after treatment. ClA, UN, and a mixture of equal parts of these two acids were equally effective at a total concentration of 1 per cent.

In one experiment, plots 4 rows wide and 10 ft. long were prepared 7 days before planting to snap beans (var. Tendergreen). One per cent solutions of ClA, UN, and mixtures of these two were compared with their respective triethanolamine salts, the sprays being applied 3 days after planting the beans. All except the amine salt of UN killed most or all weeds and gave good weed control for at least 3 weeks. The amine salt of UN killed only about 25 per cent of the weeds, but the remaining ones were injured and retarded in growth. The growth of bean plants and the yield of pods were the same in this plot as in the plot treated with the acid formulation of UN. The combined yields from plots treated with the acid and the amine salt formulation of UN were significantly greater than the yields from the two control plots (Table 1).

Table 1. Yield of snap bean from plots sprayed with 1 per cent solutions of ClA, UN, or mixtures of equal parts of each applied as pre-emergence sprays 3 days after planting and 10 days after preparation of plots.

Herbicide	Formulation	Yield of pods (oz.) for each picking			Total yield (oz.)
		First	Second	Third	
ClA	Acid	67	62	74	203
	Salt*	41	42	71	154
UN	Acid	74	45	73	192
	Salt*	80	45	68	193
ClA 0.5%	Acid	65	32	70	167
UN 0.5%	Salt*	69	30	51	150
Control	—	57	54	64	175
	—	61	34	65	160

* Triethanolamine salt.

Predominant weeds in the bean plots included purslane, crabgrass, mustard, galinsoga, and chickweed. The weed control obtained with the pre-emergence spray was reflected throughout the test, there being a 70 to 75 per cent reduction in weed growth in the plots receiving the effective treatments. The fact that no reduction in yields of bean pods occurred on plots where only 25 to 75 per cent of the weeds were killed, indicates that complete eradication of all weeds is not always a prerequisite for effective weed control.

Post-emergence applications. Post-emergence sprays, which included between-row sprays and over-all sprays were applied to plots of sweet corn, potato, cabbage, tomato, onion, and carrot. The over-all sprays caused injury to the crop plants, the degree of injury varying with the species and the age of the plants. The following crop plants are listed in order of decreasing susceptibility to 1 per cent acid sprays of ClA or UN: tomato, carrot, sweet corn, onion, potato, and cabbage. In general younger crop plants were more severely injured than older plants as in the case of weeds. For example, sweet corn up to about 12 inches in height was killed by a 1 per cent spray of UN. Corn over 12 inches could be sprayed on the basal 4 inches of the stem with a 1 per cent UN solution without injury. ClA was less toxic to corn than UN.

Between-row sprays were very effective if the sprays were applied when the weeds were 4 inches or less in height. One per cent solutions of

ClA or UN, either alone or in mixtures, killed young weed seedlings with no adverse effect on the crop plants if care was taken to direct the spray toward the base of the crop plants. On crops such as cabbage, if a few spray drops accidentally contacted the old leaves, the resulting injury was local with apparently no translocation of the chemical beyond the place of contact. Mixtures of either ClA or UN with 2,4-D proved very effective, especially on plots containing both grass and broad-leaved weeds.

In tests on sweet corn 1 per cent sprays containing the triethanolamine salt of UN were relatively more effective in killing grasses than broad-leaved weeds such as *Chenopodium album* and purslane. In contrast, the UN acid emulsion sprays killed the broad-leaved weeds as well as the grasses. The ClA sprays also showed selectivity, being less effective on grasses than on broad-leaved species. There was little or no difference in the effectiveness of the acid and salt formulations of ClA as related to selectivity.

Summary

One per cent solutions of monochloroacetic and undecylenic acids killed young weed seedlings without causing adverse residual effects on the crop when the herbicides were applied as pre-emergence and between-row post-emergence sprays. Both herbicides were selective, the degree of selectivity varying with the species of weeds and crop plants.

PRE-EMERGENCE WEED CONTROL IN LIMA BEANS AND CAULIFLOWER

by Walter C. Jacob (1)

The work reported in this paper was a continuation of work reported by Jacob and Scudder in 1949(1)*. In the previous report Dinitro formulations were satisfactory for weed control in lima beans and cauliflower but at the rates used Dinitro was effective for only three to four weeks. Since 1948 several new chemicals have shown promise for pre-emergence application to lima beans and cauliflower. The purpose of the work, herein reported, was to test out several of the new chemicals in comparison with varying rates of Dinitro with respect to crop injury and weed control in both lima beans and cauliflower.

Materials and Methods

Fordhook lima beans were sown in a newly prepared seedbed on July 12, 1950. The following day 1/2 inch of water was applied by overhead irrigation. On July 15, the materials listed in table 1 were applied to the various plots. All materials except cyanamid were applied at the rate of 100 gallons of solution per acre with hand sprayers. Each plot was 9' X 14' in size. The 25 treatments were arranged in a 5 X 5 balanced lattice square. During the 24 hour period following the spray application 1.47 inches of rain fell, beginning 16 hours after the sprays were applied. Considerable washing took place and the slightly reduced stands in general were caused by the seed being buried too deeply. In most cases the beans were above ground within 24 hours after the sprays were applied. Weed control ratings and stand counts were made on August 5, 1950.

Cauliflower

Improved Holland Erfurt cauliflower was direct seeded in the field in a newly prepared seedbed on July 25, 1950. On July 29, there was .22 inches of rainfall. The chemicals listed in table 2 part A were applied on July 31. On August 1st, there was an additional .43 inches of rain. All materials were applied at rate of 100 gallons of solution per acre on plots 12' X 25' in size. There were 5 replications of the treatments arranged in randomized blocks. The plots for transplanted cauliflower were sprayed on August 17, with the materials listed in table 2 part B. On August 18, plants were set in the plots previously sprayed. At the time of spraying there was a thick cover of weeds about 1" high since this soil had been prepared on July 27, at the same time as that direct seeded. Notes on weed control and crop growth were taken on the direct seeded crop on August 17th, and on the transplanted crop on September 16.

* Numbers in parentheses refer to literature cited.
(1) L. I. Vegetable Research Farm, Cornell University, Ithaca, New York.

Results and Discussion

Lima Bean

In table 1 the observations of weed control and crop stand are presented for each rate of each material. It can be seen that several materials failed to give weed control under the conditions of this test. Granular cyanamid was erratic in behavior and it failed to hold back any weeds. The ME 3000 series also failed to check weed growth as used here. Shell 130 was not satisfactory and the low rate of NP-128 and K-1131-NH_4 were also poor in action. T.C.A. seemed to take care of the grass but purslane was a dominant weed in this test and T.C.A. did not injure this weed at all. Premerge, Dow Gneral, K-1131-Na, and E. H. 1 were all excellent weed control agents at both high and low rates. NP-128 at 10 pounds per acre was also good as was K-1131-NH_4. The only noticable reductions in stand were the high rates of E. H. 1 and Dow General. T.C.A. did not reduce stand but it severely injured the beans about 3 weeks after emergence.

The high rates of Premerge, Dow General and K-1131-Na were effective as weed control agents until late September. No yield records were taken from the crop but when the ground was disced for the fall crop of rye on September 27, the plots of the above materials were still free from weeds. No evidence of injury was found in the rye.

The results with lima beans agree with previous work (1, 2, 3) in that Dinitro formulations seem to give good weed control with no injury to the beans. Some Dinitros are more likely to cause reduced stands in lima beans than others but at rates of about 5 to 10 pounds per acre several weeks of good weed control can be expected with little or no injury to the crop.

Cauliflower

In table 2 the observations of the effect of various chemicals on weed control and crop growth are given. When the materials were applied to direct seeded cauliflower two days after seeding the weed control ratings and stand ratings were ranged in opposite order. This is to be expected if the materials shown no selective action with respect to cauliflower. It is apparent that not one of the materials used was satisfactory for pre-emergence application to direct seeded cauliflower. With transplanted cauliflower NP-128 was the only material that gave good weed control with no injury to the crop. These plots were still free of weeds on October 28th, when the ground was disced for the winter rye cover crop. The cauliflower was good and no injurious effects were found in the cover crop.

It is evident that more work is needed to find a satisfactory pre-emergence chemical for direct seeded cauliflower. For a pretransplanting treatment, however, NP-128 seems to offer a good possibility.

Summary

1. Twelve materials at two concentrations each were applied pre-emergence to lima beans seeded in a newly prepared seedbed.

2. Premerge, Dow General and K-1131-Na, all Dinitros, gave excellent control of weeds with no crop injury for two months when applied at rates of 5 to 10 pounds active material per acre.

3. Dow General at 10 pounds and E. M. 1 at 3 pounds per acre were the only treatments to reduce the stand of lima beans.

4. None of seven materials tried was satisfactory for pre-emergence application to direct seeded cauliflower.

5. NP-128 at 10 pounds per acre was satisfactory for a pretransplanting treatment for cauliflower, providing 2 months of weed control with no injury to the cauliflower crop.

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Table 1. Influence of Various Chemical Herbicides on the stand of Lima Beans and the associated weed control ratings.
(All applications made 3 days after seed was sown)

Material Used		Rate per acre of active ingredient	Ave. weed* control rating	Stand of Plants in 5' of row
Premerge	(5)	5#	8.4	11.2
Dow General		10#	8.4	4.9
Premerge		10#	8.2	7.6
Dow General	(5)	5#	8.2	8.0
K-1131-Na	(3)	10#	7.9	7.2
E. H. #1	(4)	3#	7.3	5.0
K-1131-Na		5#	6.7	6.0
NP-128	(2)	10#	6.5	12.4
E. H. #1		1.5#	6.3	7.2
$K-1131-NH_4$	(3)	10#	5.9	9.4
Shell 130	(7)	10 gal.	3.9	9.8
$K-1131-NH_4$		5#	3.6	9.8
M. E. 3001	(1)	3#	3.6	7.4
T.C.A.	(6)	15#	3.2	9.8
Cyanamid (granular)		400#	2.9	8.6
Shell 130		5 gal.	2.8	9.4
NP-128		5#	2.4	9.1
M. E. 3002	(1)	3#	2.3	8.2
M. E. 3002		1#	2.1	7.5
T.C.A.		10#	2.1	8.9
M. E. 3000	(1)	1#	1.9	8.1
M. E. 3001		1#	1.5	6.5
M. E. 3000		3#	1.3	12.2
Cyanamid (granular)		200#	1.0	8.0
Check		-----	1.3	9.9
L.S.D. @ P		.05	2.7	4.8

* Key to weed control ratings
1 = no weed control.
9 = perfect weed control - no weeds.

(1) ME3000, 3001, 3002 - various formulations of Disodium 3, 6 - endoxohexahydropthalate furnished by Niagara Chemical Division, Middleport, New York.
(2) NP-128 - a material to be compared with Dinitros, furnished by Penn. Salt Mfg. Company.
(3) K-1131 - a material to be compared with Dinitros, furnished by Koppers Company, Inc.
(4) E. H. 1 - Sodium 2,4-Dichlorophynoxyethyl sulfate furnished by Carbide & Carbon Chemical Corp.
(5) Premerge & Dow General - Dinitros furnished by Dow Chemical Corp.
(6) Sodium trichloroacetate - 70% formulation furnished by Du Pont.
(7) Pentachlorophenal in oil - furnished by Shell Chemical Corp.

Table 2. Influence of Various Chemical Herbicides on the stand of Cauliflower and the associated weed control ratings.

Material		Rate of active ingredients per acre	Average weed* control rating	Plant stand** rating
		A. Cauliflower Direct Seeded		
Dow General	(5)	5#	9.0	1.0
Premerge	(5)	5#	8.8	1.0
K-1131-Na	(3)	5#	7.8	1.2
NP-128	(2)	5#	5.8	3.0
E. H. #2	(4)	10#	5.6	3.8
ME 3000	(1)	3#	5.0	5.8
Shell 130	(6)	5 gal.	4.2	6.0
Check		------	1.0	7.8
L.S.D. @ P	.05		1.5	1.7
		B. Cauliflower Transplanted		
Dow General	(5)	5#	9.0	6.6
K-1131-Na	(3)	10#	8.8	3.0
NP-128	(2)	10#	8.6	9.0
Premerge	(5)	5#	6.4	7.8
Shell 130	(6)	5 gal.	5.2	9.0
ME 3000	(1)	3#	2.0	9.0
E. H. #2	(4)	10#	1.4	7.4
Check		------	7.2	9.0
L.S.D. @ P	.05		1.5	2.6

* Key to weed control ratings
1 = no weed control.
9 = perfect weed control - no weeds.

** Key to plant stand ratings
1 = no cauliflower present.
9 = perfect stand of plants.

(1) See note 1 table 1.
(2) See note 2 table 1.
(3) See note 3 table 1.
(4) Dichloral urea furnished by Carbide and Carbon Chemicals Corp.
(5) See note 5 table 1.
(6) See note 7 table 1.

Pre-emergence Weeding of Spinach with Chemical Herbicides

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The cost of weed control in spinach is very high and represents a large percent of the total cost of growing of the crop. Never the less little research has been reported on the use of chemical herbicides for control of weeds in this crop. Lachman (1) reports fairly successful method of weed control using pre-emergence herbicides. The practice reported required careful seed bed preparation, a delay in planting, exact timing of the application of the herbicide, and also the use of a non-residual herbicide.

Work of Noll and Odland (2) indicates that a number of chemical herbicides, not requiring exact timing, might be used successfully in a pre-emergence treatment. Further results of this work which was started in 1949 are presented in this paper.

The tests were conducted on Hagerstown silt loam soil at State College. The weed population was largely purslane, red root pig weed and annual grasses. The variety of spinach grown was Bloomsdale Long Standing. Because it was expected that some of the chemicals used would reduce the stand of spinach two seeding rates were used, the normal rate of about 12 lbs. per acre, and double this rate or about 24 lbs. per acre.

The land was all prepared at one time. Two seeding dates were used. The first seeding was done 3 days after the land was prepared and the second seeding was done 16 days after the land was prepared. Herbicides were applied 2 to 3 days prior to the emergence of the spinach. Herbicides were applied with a knapsac sprayer and all rows were cultivated with conventional equipment. No hand weeding was done on any treatment.

Individual plots were one row wide and forty feet long. Distance between rows was 18 inches. All treatments were replicated 6 times. Weights of spinach and weeds in the row were taken at harvest time.

A list of the chemicals used and the data obtained on yield of spinach and weight of weeds per plot is presented in Table 1.

No treatment gave a significant increase in yield of spinach as compared to the check. Only two plots in the normal seeding planting gave as good a yield as the check with a significant increase in weed control. These two treatments were Shell Oil 130 at 15 gal. per acre and Experimental Herbicide No. 2 at 7 lbs. per acre. Eight plots in the delayed seeding experiment gave a yield equal to the check with a significant increase in weed control. These eight treatments were Stoddard Solvent at 100 gal. per acre, Fuel oil at 18 gal. per acre, Shell oil at 5 gal. and 10 gal. per acre, N P 128 at 7, and 10 1/2 gal. per acre and Aero Cynate Weed Killer at 20 and 30 lbs. per acre.

There were very few weeds in the row when delayed seeding was practice. Probably the disturbing of the soil in the row by the planting operation eliminated many of the weeds at time of seeding.

The heavier seeding rate produced an average of 38% more spinach per plot.

Summary

The value of eleven chemicals for pre-emergence weed control in spinach was studied. Treatments included two seeding rates, two planting dates, and from 1 to 3 rates of treatment per chemical.

No chemical gave an increase in yield of spinach per plot. Two chemicals in the normal seeding plots and 5 chemicals in the delayed seeding plots gave as good a yield as the untreated and a significant increase in weed control.

Where a delay in seeding was practiced all chemicals gave a significant increase in weed control as compared to the check.

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Table 1. The effect of pre-emergence herbicides on the weed population and yield of spinach.

Material and Amount per acre	Normal Seeding			Delayed Seeding		
	Spinach		Weeds	Spinach		Weeds
	Normal Rate	Double Rate		Normal Rate	Double Rate	
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1. Water	9.08	9.90	1.03	7.35	9.58	0.69
2. Stoddard Solvent 100 gal.	9.42	9.67	2.27	4.50	3.40	0.27
3. Fuel oil 18 "	10.52	12.88	1.18	7.78	11.17	0.24
4. Shell Oil 130 5 "	11.00	8.57	1.24	7.88	9.33	0.04
5. Shell Oil 130 10 "	5.70	9.67	0.94	6.50	8.53	0.03
6. Shell Oil 130 15 "	8.46	10.23	0.57			
7. Sinox W 3 "	0.30	2.23	0.67	3.67	5.30	0.10
8. Sinox W 4-1/2"	0.05	0.42	0.73	1.60	3.81	0.08
9. Dowicide G 20 lbs.	1.17	4.17	0.34	1.70	3.13	0.02
10. Dowicide G 30 lbs.	0.03	0.62	0.13	0.02	0.20	0.02
11. Dow Selective 3 gals.	0.15	1.43	0.60			
12. Dow Selective 3-1/2 "	0.13	0.65	0.40			
13. NP-128 7 lbs.				7.15	9.27	0.08
14. NP-128 10-1/2 "				5.43	6.50	0.05
15. Premerge 1 gal.	3.20	11.13	0.67	0.45	3.43	0.06
16. Premerge 1-1/2 gal.	0.38	3.78	0.67	0.02	0.52	0.03
17. ACP 646A 1-1/2 "	1.97	3.83	0.71	0.43	1.52	0.01
18. ACP 646A 2-1/4 "	0.85	1.12	0.52	0.48	0.95	0.02
19. Exp. Herb. #2 7 lbs.	8.43	12.12	0.56	4.63	5.12	0.18
20. Exp. Herb. #2 10-1/2 "	8.50	7.27	0.86	4.67	6.25	0.16
21. Aero Cynate W.K. 20 lbs.	8.68	12.25	2.38	7.23	7.78	0.13
22. Aero Cynate W.K. 30 lbs.	8.43	11.25	1.24	7.38	8.48	0.13
Significant Difference 5%	4.91		0.59	3.05		0.18
Significant Difference 10%	6.47		0.78	4.03		0.23

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Calcium Cyanamide for Pre-emergence Weed Control and Fertilization in Canning Peas, New York State, 1950

Peter Hahn[1]

Calcium cyanamide[2] has been used as a pre-emergence weed control agent in a variety of crops including asparagus (1), onions (3), and corn (2). Work of this kind has led to weed control experiments with cyanamide on other crops. This paper reports on a series of experiments conducted in New York State in the summer of 1950, in which granular cyanamide was tested under field conditions for weed control and fertilization of canning peas.

Granular cyanamide is a 20.6% nitrogen material supplying the equivalent of 70% hydrated lime. Upon contact with moist soil, cyanamide hydrolyzes according to the following schematic equations:

$2CaCN_2 + 2H_2O$ calcium cyanamide	--->	$Ca(HCN_2)_2$ calcium acid cyanamide	+	$Ca(OH)_2$ calcium hydroxide
$Ca(HCN_2)_2 + 2H_2O$ calcium acid cyanamide	--->	$2H_2CN_2$ hydrogen (or free) cyanamide	+	$Ca(OH)_2$ calcium hydroxide
$2H_2CN_2 + 2H_2O$ hydrogen cyanamide	--->	$2H_2NCONH_2$ urea		

The calcium acid cyanamide and free cyanamide released during this hydrolysis are toxic to weed seeds and to most plant growth and are the weed killing agents. As shown, they in turn hydrolyze to urea which, upon further decomposition, furnishes nitrogen for the crop.

It has been noted that many crops with large seeds, such as peas, corn and beans, show a relatively high tolerance for cyanamide toxicity while small-seeded plants as a group, including most weeds, are more susceptible. The high tolerance of peas was reported on by the Swedish workers, Osvald, von Hofsten and Persson (4). In using the material for pre-emergence weed control, it is broadcast on the top of the soil before emergence of the peas and thus separated from the crop seed. This separation, plus the inherent tolerance of peas for the breakdown products of cyanamide, form the basis for the use of the material for pre-emergence weed control in this crop.

PLAN OF FIELD TESTS

All the work was done with farmer-cooperators who assigned a portion of their regular acreage for experiment. The crop was fertilized and seeded in the normal way. Three to ten days after seeding, 200 to 400 pounds per acre

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1. Agriculturist, American Cyanamid Company
2. Available commercially as 20.6% AERO Cyanamid, Granular.

of granular cyanamide were broadcast evenly over the soil surface and allowed to remain undisturbed. Application was delayed after seeding in order to synchronize the breakdown of the cyanamide with germination of the weed seeds. If application were made the day of seeding, the cyanamide could, under some conditions, convert to urea before the weed seeds begin to germinate. Dormant weed seeds are relatively resistant to cyanamide breakdown products. During cool weather, application was delayed longer in order to allow for the slower weed seed germination. Toward the end of the planting season, when the weather warmed, application was made as soon as three days after seeding. Five to six days was the average and can be expected to give good results under most conditions.

Granular cyanamide is a free-flowing material and was applied with the different types of distributors commonly available on the farm, including lime and fertilizer spreaders, grain drills with spouts removed, and simple, gravity-feed Cyanamid spreaders. A splash board was attached under equipment not normally equipped with one in order to give uniform distribution of the granules.

The tests were carried on at twenty-two different locations, with one area, one to four acres in size, treated at each location. By carrying on this range of work, a wide variety of conditions of temperature, moisture, soil fertility and weed population were encountered. In getting yield figures, at least 1/3 of an acre was harvested on a treated area and a similar area was harvested on an adjacent untreated portion of the field for comparison. In all cases the harvested areas were strips running the length of the field so that the influence of local variations in topography, soil fertility, etc., were held to a minimum. The harvested peas were run through commercial viners. By harvesting plots of this size, the percentage error incurred by the loss of several pounds of shelled peas during operations, was small. Tenderometer readings were obtained (as well as the yield figures) through the cooperation of a number of canning companies.

RESULTS

Pea fields in New York State are generally cultipacked or flatrolled after seeding, primarily to push stones into the ground that might otherwise interfere with harvesting. The ridges caused by cultipacking might be expected to interfere with even distribution of the cyanamide granules and consequently with weed control. This, however, did not appear to be the case since applications on both types of seedbeds gave good control.

Weeds satisfactorily controlled were mustard, lamb's quarter, red root pigweed, and ragweed. In some instances the material depressed the growth of perennial grasses and Canada thistle, but in neither case was control consistent. In general, perennials cannot be controlled by this method.

No significant retardation of seedling growth of peas was observed on any of the test plots with rates as high as 400 pounds per acre, nor in cases where heavy rains followed application.

It appears that 250 to 300 pounds per acre is the preferred rate, considering the several points of weed control, crop response, and cost to the farmer. Within the wider range of 200 to 400 pounds per acre, weed control was not significantly different at either extreme. The timing of application to coincide with weed seed germination is an important factor affecting weed control.

In general, cyanamide treatments markedly increased yield, and improved quality of the peas as measured by the tenderometer. The tenderometer measures the quality of the peas by determining their softness, which is related to the degree of maturity. Nitrogen has the effect of delaying the maturity of the peas (5). By using this information, a farmer can do one of two things depending on the relative importance of yield and quality in his market's price structure. In a field treated with extra nitrogen he could obtain a yield equal to that obtained on an untreated field, but of better quality as would be shown by a lower tenderometer reading. On the other hand, he could allow a treated field to come to the same stage of maturity, i.e. same tenderometer reading, before harvesting, as an untreated field and expect a substantially higher yield from his treated field. In these tests, both an increase in yield and a better quality were obtained at most locations.

It should be pointed out that the lower the tenderometer reading, the better the quality of the peas. A swing of five points often means a substantial difference in price per ton. Generally, peas are harvested at readings of 90 to 105 or 110. Table 1 shows results of six experiments representing the range of results obtained in the 22 experiments. Experiments 1 and 2 are representative of most of this work. Each shows a significant increase in yield and quality. Experiment 3 shows the effect of a heavy grass infestation. Control of grass was poor, and since grass competes strongly for the released nitrogen, little effect was noted on the crop. Experiment 4 shows the result of treatment in a field where the stand of peas was thin due to maggot injury and root rot. Weed control in thin stands of peas is generally poor. Normally the peas would shade out later crops of weeds after chemical treatment has taken care of the weeds germinating early. In poor stands the ground is not sufficiently shaded and weeds sprout after the toxicity is gone from the soil. In this experiment the low acre yields reflect the thin stands in the check and treated area alike. However, there is an increase in yield and a markedly lower tenderometer reading in the treated plot. Experiment 5 shows a very large increase in yield; the tenderometer reading is not in favor of the treated area, but even allowing for this, the benefit of the cyanamide application is substantial, measured in cash return for the extra yield. Experiment 6 shows the yield slightly in favor of the untreated plot, but this is outweighed by the 6 points difference on the tenderometer in favor of the treated plot.

DISCUSSION

The New York State Agricultural Experiment Station reported on this method of weed control in peas in the last edition of their quarterly publication, "Farm Research" (5), as an addition to those materials currently recommended, which include spray materials and calcium cyanamide dust. These are all post-emergence treatments. The chief advantages of the granular cyanamide, pre-emergence method reported here, are the ease of application and, more important, the use of a nitrogen fertilizer for its combined fertilizer and weed control value.

It was noted that increases in yield and quality as a result of treatment were most notable on those fields which were already in a state of high fertility. This was true, for example, of experiments 1 and 2 (table). Both of these fields had received 100 pounds of nitrogen in a mixed fertilizer before the cyanamide was applied. Total nitrogen on these fields, where treated, was 140 - 160 pounds. On the other hand, experiment 4 was carried on in a field of low fertility that had only 200 pounds of a 3-12-6 fertilizer applied before treatment.

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TABLE 1. THE EFFECT OF CYANAMIDE ON WEED CONTROL AND ON YIELD AND QUALITY OF CANNING PEAS

Experiment	Cyanamide Lbs./Acre	Area Harvested	Yield Shelled Peas Lbs./Acre	Net Effect on Yield, Lbs./Acre	Tenderometer Reading	Weed Control
1.	225	1/3 Acre	3850	510 incr.	105	Excel.
	None	1/3 Acre	3340		110	
2.	300	1/2 Acre	3300	370 incr.	109	Excel.
	None	1/2 Acre	2930		115	
3.	225	1/3 Acre	2400	150 incr.	93	Poor
	None	1/3 Acre	2250		90	
4.	250	1/2 Acre	830	100 incr.	82	Poor
	None	1/2 Acre	730		95	
5.	250	1 Acre	2320	900 incr.	120	Excel.
	None	1 Acre	1420		108	
6.	250	1 Acre	3100	100 decr.	92	Fair
	None	1 Acre	3200		98	

THE EFFECT OF TEMPERATURE, RELATIVE HUMIDITY AND WIND ON THE CONTROL OF PURSLANE WITH AERO CYANATE*

Joe Antognini[1]

At the present time Aero Cyanate is the only herbicide used on a commercial scale for weed control in onions in New York State. Even though this material is used by many commercial growers numerous cases have been reported, both by growers and research workers, of very poor weed kill even with weeds no larger than the four leaf stage. The poor results in most cases were obtained when the principal weed present was purslane (Portulaca oleracea). Some observations indicated that the poor results might have been due to rapid evaporation of water from the cyanate solution on the surface of the weeds. To test the effects of temperature, humidity and wind movement on the usefulness of cyanate for weed control the following experiments were conducted.

Since the difficulty was mainly in the control of purslane and also because most muck farmers in New York State consider purslane to be their chief weed problem it was used in the work.

Materials and Methods

Controlled conditions of temperature, relative humidity and wind were maintained by the use of a wind tunnel placed in a storage room. Three temperatures (60°, 75° and 90° F.), three relative humidities (35-40%, 65-70% and 95-100%) and three winds (0, 6 and 12 M.P.H.) were used.

The wind tunnel was constructed of ¼" plyboard and galvanized sheet metal. It was two feet high, two and one-half feet wide and six feet long. The top was two and one-half feet wide at the base and tapered to the peak which was one foot high. Mounted in the peak of the tunnel top were Sylvania 40 W Daylight fluorescent tubes which gave a light intensity of 900 f.c. at the plant level. The entire tunnel was mounted on a one and one-half foot high platform to allow for better air circulation. The storage room in which the tunnel was placed was seven feet wide, twelve feet long and seven feet nine inches high. The room was equipped with a brine cooling system to maintain temperatures of 60° F. or below.

The temperatures of 75 and 90° F. were maintained by the use of an electric heater connected to a thermostat. The brine cooling system was turned on in the storage room to maintain the temperature of 60° F. Hygrothermograph records showed that the variability in temperature was plus or minus two degrees.

*Trade name for potassium cyanate manufactured by the American Cyanamid Company.

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Calcium chloride was used to maintain the relative humidities of 35-40% and 65-70%. Empty fertilizer bags were placed on the floor and the calcium chloride spread out over them in a layer one to two inches thick. The amount of calcium chloride used for a given relative humidity varied depending on the temperature being used. Sprayco atomizers were used to maintain the relative humidity at 95-100%.

A 24" 6-bladed Aerovent fan was used to create wind in the tunnel. The fan was mounted at one end of the tunnel pulling air through the tunnel. At the opposite end from the fan were mounted three baffles each of which was nine inches wide and two feet eight inches long. The desired wind velocities were obtained by placing the baffles in given positions which had been calibrated by the use of a Tycos hand anemometer.

The purslane was seeded broadcast in flats 7" x $11\frac{1}{2}$" x $2\frac{1}{2}$" which were filled with sterilized muck. The seeding was done 8 days before the various treatments were applied. The flats were placed in the warm greenhouse and watered immediately after planting, three days after planting and 6 days after planting. This watering schedule was followed to harden the plants off so differences in per cent kill would be wider than if the plants were succulent.

At the time the flats were placed in the wind tunnel the majority of the plants had four true leaves. Before the flats were placed in the wind tunnel fifty purslane plants were counted in each of the four replications in a given section of the flat and counted again three days after application of the treatment to determine the per cent kill.

The plants were placed in the wind tunnel under the desired conditions for one hour prior to application of a 1% Aero Cyanate spray at the rate of 60 gallons per acre. After application of the spray the flats remained in the tunnel for four hours and then removed to the greenhouse. The above periods of one hour and four hours were used as a result of preliminary studies under controlled conditions and in the field.

Results

As shown in Table 1 and Figure 1, temperature, relative humidity and wind all influenced the effectiveness of cyanate in killing purslane.

Temperature markedly affects the action of Aero Cyanate when the relative humidity is 65-70% or 35-40% and when the wind velocity is six and twelve miles per hour. Under a given set of the conditions mentioned the lower the temperature the higher the per cent kill of purslane.

Relative humidity exerts its greatest influence when the temperature and wind velocity are high. When the relative humidity is 95-100%, however, 100% kill is obtained regardless of the temperature and wind used. When the relative humidity is 65-70% the per cent kill drops off markedly with an increase in either temperature or wind. At a relative humidity of 35-40% the per cent kill drops off to as low as 0% kill at 90° F. with a six mile per hour wind and at 75° F. and 90° F. with a wind of twelve miles per hour.

The effect of wind is greater the lower the temperature and relative humidity. Under a given set of conditions of temperature and relative humidity the higher the wind velocity the lower the per cent kill of purslane with the exception of 95-100% relative humidity. With a relative humidity of 95-100% and temperatures of 60,75 and 90° F. the kill obtained was 100% regardless of wind velocity.

Table 1. The effect of temperature, relative humidity and wind on the control of purslane with Aero Cyanate.

90° F.

Wind (m.p.h.)	Per cent kill of purslane 35-40% R.H.	65-70% R.H.	95-100% R.H.
0	47.50	92.50	100.00
6	0.00	84.50	100.00
12	0.00	79.00	100.00

75° F.

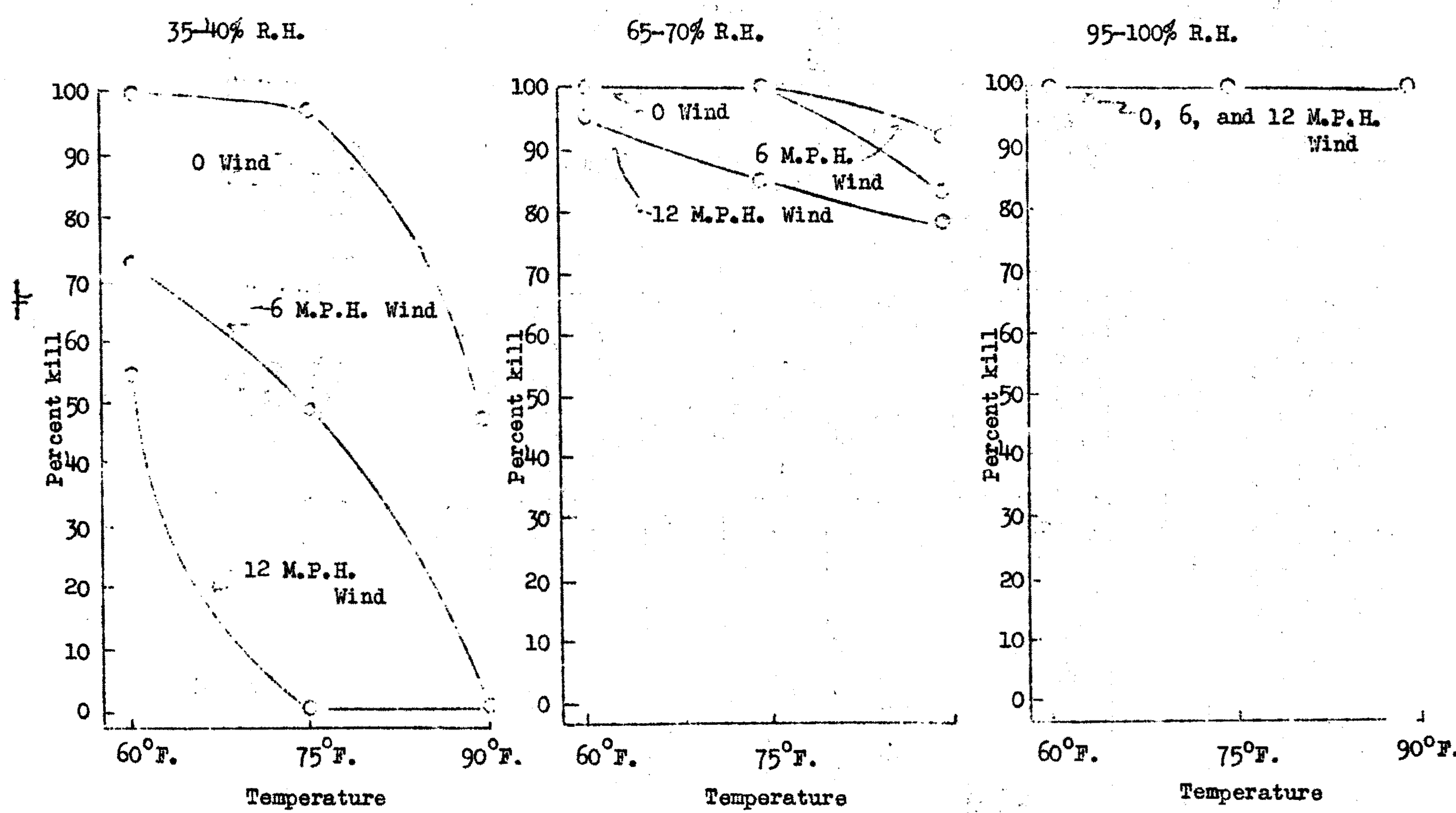
Wind (m.p.h.)	Per cent kill of purslane 35-40% R.H.	65-70% R.H.	95-100% R.H.
0	98.50	100.00	100.00
6	50.00	100.00	100.00
12	0.00	85.50	100.00

60° F.

Wind (m.p.h.)	Per cent kill of purslane 35-40% R.H.	65-70% R.H.	95-100% R.H.
0	100.00	100.00	100.00
6	72.50	100.00	100.00
12	55.00	95.50	100.00

Figure #1

THE EFFECT OF TEMPERATURE AND WIND ON PERCENT KILL OF PURSLANE AT 35-40%, 65-70% and 95-100% RELATIVE HUMIDITY



Conclusions

Under the conditions of these experiments the effectiveness of Aero Cyanate in killing purslane was greater the higher the relative humidity, the lower the temperature and the lower the wind velocity. This effectiveness is believed to be due to a decreased evaporation rate which allows the Aero Cyanate solution to remain on the leaves for a much greater length of time than occurs when the rate of evaporation is high.

The results together with observations of the author and some growers suggest that for best results with Aero Cyanate as an herbicide against Portulaca oleracea spraying should be done in the early morning hours and in the evening thereby avoiding spray applications when the temperature and wind movement may be high and the relative humidity low.

Weed Control in Set Onions And Sweet Corn

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Within the last ten years a number of chemicals have been developed that have definite herbicidal properties. A few of these chemicals display a selective herbicidal action but for the most part they are general in their action. From this standpoint it seems reasonable to test the value of many of these herbicides as pre-emergence weed killers where the toxic material is applied to the soil and not the crop plant.

The culture of set onions and sweet corn are important enterprises in Massachusetts and the problem of weed control is always important in the culture of these crops. During the last three years experiments have been conducted to determine the value of several herbicides in pre-emergence applications to these two crops. The purpose of this paper is to present the results of the work pursued during 1950.

MATERIALS AND METHODS

Nineteen treatments were applied to plots of Golden Jewel sweet corn and these were replicated four times. The plots consisted of four 24-foot rows each and the seed was planted by hand with the rows spaced 3 feet apart and the seed 9 inches apart in the row. Records were taken from the two middle plot rows only. The soil was a Scarborough very fine sandy loam with a rather impervious subsoil and was considered to be low in fertility. It was prepared in the normal manner and a 5-10-5 fertilizer was broadcast at the rate of 1800 pounds per acre. The corn was planted on May 22 which is eight days after the average date for the last spring frost in this locality. The growing season was much colder and drier than ordinarily expected.

The following chemicals with their respective per acre rates were applied to the corn one day after planting: 20 and 30 pounds of Sodium Pentachlorophenate, 3, 6 and 9 pounds of DNOSBP in Dow General, 3, 6 and 9 pounds of DNOSBP in Dow Premerge, 20 and 30 pounds of Pentachlorophenol in Dow H-916, 5 and 10 gallons of Shell Weedkiller 130, and 400 pounds of Granular Cyanamid. Experimental Herbicide No. 1 was applied at the rate of 1, 3 and 6 pounds per acre 5 days after planting and 1.5 pounds of 2,4-D acid equivalent as the sodium salt and 400 pounds of Granular Cyanamid were applied 8 days after planting.

Nineteen treatments were also applied to plots of Ebenezer onions and these were replicated three times. The plots consisted of five 15-foot rows each and the sets were planted by machine with the rows spaced 15 inches apart. Records were taken from the three middle plot rows only. The soil was a Hadley fine sandy loam and was low in fertility. It was prepared in the normal manner and a 5-10-5 fertilizer was broadcast at the rate of 2000 pounds per acre. The sets were planted on April 29 which is about 15 days later than normal planting time in this area.

The following chemicals with their respective per acre rates were applied to the onions three days after planting: 100, 200 and 400 pounds of Granular Cyanamid, 20 and 30 pounds of Sodium Pentachlorophenate, 3, 6 and 9 pounds of DNOSBP in Dow General and, 3, 6 and 9 pounds of DNOSBP in Dow Premerge. Further treatments when the first weeds appeared were 100, 200 and 400 pounds of Granular Cyanamid. To study further the effect of delayed application of Granular Cyanamid, plots were treated with 100 and 200 pounds of this material and then retreated on May 30 when onions were six inches tall in such a way that all combinations of 100 and 200 pounds of Granular Cyanamid were included in these tests.

With the exception of the Cyanamid all chemicals were diluted with water and applied at the rate of 100 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 and the rate of application was regulated so that the plots were covered twice at any given application to assure as uniform application as possible.

The following weeds were present abundantly and fairly uniformly throughout the experimental area: purslane, shepherd's purse, smartweed, chickweed, lamb's quarters, pigweed, galinsoga and wiregrass. A rather sparse and variable stand of nutgrass was present on the site of the sweet corn experiment and because of the variable stand this weed was not included in the weed counts which were made on June 15.

All of the sweet corn plots were cultivated and hand hoed on June 20 and were also cultivated twice later. All of the onion plots were cultivated on June 15 followed by three more cultivations.

RESULTS AND DISCUSSION

The results of these investigations with corn are presented in Table I.

Germination of the corn was not affected adversely by the treatments except for Cyanamid when applied one day after planting but even here the reduction in stand was not significant at the 1 percent point. The effect of the chemicals in controlling weeds is particularly noteworthy. The poorest treatments from this respect were those involving Experimental Herbicide No. 1 but here one pound of the material reduced the number of weeds by half the number found in the control. Another significant point is the fact that the eight day delayed application of cyanamid was much more effective in controlling weeds than the one day delayed treatment of the same compound. The sodium pentachlorophenate, Dow General, Premerge, H-916, and eight day delayed Cyanamid treatments were all considered to be very effective in preventing weed growth.

The growth of weeds that survived the treatments was not excessive in many of the tests when rated on June 15. At this time the corn was about seven inches tall. It was felt that where weeds are controlled adequately by chemicals up until the time corn is six inches tall the method is well worth while. Most troubles with weeds are encountered before this stage of crop development and herein lie most of the difficulties where cultivation alone is practiced.

Crop damage, rated on a basis of one to ten, was greatest in the Experimental Herbicide No. 1 and 2,4-D plots. Least damage was apparent on the sodium pentachlorophenate, Cyanamid, Shell 130 and 3 lb. DNOSBP Dow General plots. Total growth as measured on June 15 was seriously delayed by the 6 pound Experimental Herbicide No. 1 treatment. This treatment also was responsible for a significant reduction in marketable and total yield of ears. It is rather interesting that none of the other differences in yield are significant when comparisons are made with the control.

The results presented in Table II indicate that the treatments significantly reduced the stand of weeds in onions but few of them were particularly remarkable in this respect. The best treatments here were 30 pounds of Sodium pentachlorophenate and 9 pounds of DNOSBP in Dow General with an average stand of 3.3 and 8.6 weeds per square foot respectively. When considering the effect of the treatments on the size of weeds that survived more significance can be ascribed to the value of the various chemicals as onion herbicides. Here it is evident that more weeds are present than in the experiment previously described with corn but the size of the weeds present in many cases are so small as to make their presence of relatively small importance.

Crop damage as a result of chemical action was greatest where Dow General and Premerge were used and this is also reflected in the yields of the plots, especially where the highest dosages are indicated. Here again the value of Sodium pentachlorophenate makes itself apparent as a pre-emergence herbicide.

Yields on the plots of the Control are lower than many of the treatments and it is suspected that weed competition before cultivation on June 18 is responsible for this.

Conclusions

It appears plausible that chemicals can be used for weeding sweet corn and onions in pre-emergence applications. It was not possible to keep the land free of weeds throughout the growing season, however, with the treatments used in these experiments.

It was rather apparent that onions were more subject to injury by the dinitros than was the corn. Experimental Herbicide No. 1 was not very effective in controlling weeds when compared with the other chemicals used.

Twenty to thirty pounds of Sodium pentachlorophenate was perhaps the most effective of the materials used.

Table I - Effect of Chemicals on Weed Control, Damage Growth and Yield of Golden Jewel Sweet Corn Planted May 22, 1950.

Treatments Rates per Acre	Germination (Perfect Stand-66)	Number of Weeds per Sq. Ft.	Weed Size Rated 1-10	Apparent Crop Damage Rated 1-10	Height of Corn inches	Mktable Ears Pounds	Total yield pounds
Applied 1 day after planting							
Sodium pentachlorophenate							
20 pounds	49.00	.75	0.50	3.25	7.25	40.25	48.50
30 pounds	51.50	.50	0.25	3.00	7.50	38.75	50.25
Dow General							
3 pounds DNOSBP	50.25	3.75	1.50	3.00	7.75	42.00	50.25
6 pounds DNOSBP	43.50	.50	.50	5.50	6.00	33.75	40.75
9 pounds DNOSBP	49.25	.25	.50	4.75	6.75	36.25	45.50
Dow Premerge							
3 pounds DNOSBP	48.00	7.50	1.75	4.00	6.50	35.00	47.50
6 pounds DNOSBP	51.00	2.25	1.25	5.00	6.75	35.25	45.75
9 pounds DNOSBP	52.50	0.00	0.00	6.50	6.50	33.50	40.25
Gran. Cyanamid							
400 pounds	42.25	42.50	6.00	2.50	8.00	37.50	47.00
Shell Weedkiller 130							
5 gallons	48.75	27.75	5.00	3.25	7.50	37.25	48.75
10 gallons	50.50	13.00	3.75	3.50	7.50	34.25	40.25
Dow H-916							
20 pounds	51.50	0.25	0.25	4.25	7.00	38.00	48.25
30 pounds	48.50	0.00	0.00	4.75	6.75	39.25	51.00
Applied 5 days after planting							
Experimental Herbicide No. 1							
1 pound	50.75	32.50	5.25	5.00	6.00	34.50	43.75
3 pounds	50.00	23.75	4.75	5.75	6.00	34.25	41.75
6 pounds	48.00	18.00	3.25	8.75	4.50	24.50	32.0
Applied 8 days after planting							
Gran. Cyanamid							
400 pounds	52.25	5.25	2.00	3.00	7.75	41.75	47.75
2,4-D Sodium salt							
1.5 pounds acid equiv.	47.75	11.25	2.00	7.50	5.75	31.50	41.75
Control-First cultivation - June 22	47.25	63.25	9.75	1.00	8.50	38.25	47.50
L.S.D. 5 percent	5.1	17.60	1.32	2.14	1.46	8.64	7.5
1 percent	6.8	23.40	1.75	2.84	1.51	11.50	9.9

Table II - Effect of Chemicals on Weed Control, Damage to Crop, and Yield of Ebenezer Onions Planted April 29, 1950

Treatments Rates per Acre	Number of Weeds per Square Foot	Weed Size Rated 1-10	Apparent Crop Damage Rated 1-10	Marketable Yield Pounds per Plot
Applied May 2				
Gran. Cyanamid				
100 pounds	20.6	5.67	1.00	22.6
200 pounds	28.3	4.67	1.00	19.6
400 pounds	20.3	3.00	1.00	21.0
Sodium pentachlorophenate				
20 pounds	10.0	2.00	1.67	23.3
30 pounds	3.3	1.00	2.00	20.3
Dow General				
3 pounds DNOSBP	23.0	2.00	4.00	15.0
6 pounds DNOSBP	16.3	1.67	5.67	14.3
9 pounds DNOSBP	8.6	1.00	8.00	9.0
Dow Premerge				
3 pounds DNOSBP	21.6	2.00	2.67	18.3
6 pounds DNOSBP	20.3	1.67	4.67	15.6
9 pounds DNOSBP	13.0	1.00	6.67	11.6
Applied May 15 - appearance of first weeds				
Gran. Cyanamid				
100 pounds	37.3	6.67	1.00	16.6
200 pounds	33.3	5.67	1.00	18.3
400 pounds	28.0	3.00	1.67	18.0
100 pounds + 100 pounds May 30	36.6	7.00	1.33	17.3
100 pounds + 200 pounds May 30	37.0	7.67	1.33	18.6
200 pounds + 100 pounds May 30	36.0	5.67	1.00	18.6
200 pounds + 200 pounds May 30	32.3	4.00	1.00	23.3
Control - First cultivated June 18	55.3	9.00	1.00	16.3
L.S.D. 5 percent	8.1	1.90	1.17	6.6
1 percent	11.0	2.55	1.48	8.8

Some Variations in Weed Control on Potatoes

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Treatments (Pre-emergence)	Weeds per 50' of row Grass	Dicot	Top Dam.	Stand Dam.	Yd. Bu. per A
1200 lbs. Cyanamid	6	0	None	10%	555.0
800 lbs. Cyanamid	10	0	None	1%	517.0
Herb.1. 5#(Na2-4 di. sulfate)	3	3	leaves crinkled	1%	508.0
Herb.2. 5# (Dichloral Urea)	10	1	None	None	555.0
Dowcide G. 20# (Na penta.)	1	1	slight	1%	569.7
Dowcide G. 10# + 2# micro 2,4-D	6	0	leaves crinkled	1%	528.5
Premerge 1 gal. (Amine ONOSBP)	12	12	None	None	508.0
Premerge 2 gal.	8	1	None	5%	466.5
Sinox Gen. 1 qt.	8	1	None	0	579.0
Sinox Gen. 2 qt.	3	0	None	0	572.0
No treatment	30	500	None	0	425.5
Dow Selective 3 qt. (Post.)	17	150	25% burned	0	550.0

The above test was applied during a wet spell after the weed growth was well established about two inches high, just before the potato plants emerged. The weeds were mostly mustard and a few other annuals.

This same test applied in another location later in the spring during a dry spell showed very little difference in weed control over the no treatment plots, all of which indicates that judgement must be used on the weather with chemical weed control.

The only significant yield is that of the check plot where the weeds were so thick that the yield could not come up to the lowest treated plots.

The field adjacent to the test plots yielded around 600 bushels. It was weeded twice besides several cultivations. The rows were also side dressed twice with nitrogen. Any weeds in the field rows were pulled out by hand. All this extra labor cost much more than the treatments.

A COMPARISON OF CULTIVATION WITH CHEMICAL WEED CONTROL IN POTATOES

by J. Howard Ellison and Walter C. Jacob[1]

The poor results obtained with chemical weed control compared to normal cultivation in the 1949 experiment (Proc. N. E. W. C. C., January, 1950, pp. 170-174) led the authors to believe that the drought of that season was responsible for the poor showing made by the chemicals. In 1950 it was decided to test this idea by supplying irrigation to one experiment and not the the other adjacent experiment. It was not possible to randomize irrigation as one of the factors, due to the arrangement and size of the plots.

Material and Methods

Two similar experiments, one irrigated and one not, were conducted in a field of Katahdin potatoes, which were planted April 19-21, 1950, in 34 inch rows and fertilized with 2500 pounds of 5-10-5 fertilizer. Treatments consisted of sodium 2,4-dichlorophenoxyethyl sulphate (E. H. No. 1) at 2, 3 and 4 pounds per acre; dichloral urea (E. H. No. 2) at 3, 5 and 7 pounds per acre; sodium trichloracetate (T.C.A.) at 10, 15 and 20 pounds per acre; and Premerge at 2, 3 and 4 gallons per acre. Except for Premerge all of the above rates are calculated on the basis of active ingredients. The herbicides were dissolved in water and applied on May 22 as pre-emergence sprays at the rate of 100 gallons per acre. One plot in each replication received no herbicide and was kept free of weeds by shallow hand hoeing throughout the season. The day that sprays were applied was sunny but cool and windy. The maximum temperature was 76°; minimum 45° F. The first potato plants were cracking the ground and weed and grass seedlings were emerging at the time of treatment. One-half to three-fourths of an inch of water was applied to the irrigated experiment on May 23, and on the night of May 23, 1.95 inches of rain fell. Subsequent irrigations of one inch of water each were made on June 23, July 7 and 28 and August 16.

In both the irrigated and non-irrigated experiments, the pre-emergence treatments were applied in duplicate series within each replication, so that one series of treatments could be cultivated later in the season and the other series left with no further treatment. Late cultivation was started on June 12, and from then on was handled the same as normal cultivation. Student's "t"

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was used for the statistical comparisons of normal cultivation and hand hoeing with the other treatments. Each experiment consisted of three replications; the plot size being 4 rows 21 feet in length, with the two inner rows used for records. The crop was harvested and graded September 20-22, 1950.

Results

In this paper the various treatments will be compared on the basis of their effects on yield of U. S. No. 1 potatoes. The results from the irrigated and unirrigated experiments will be presented separately, but will be brought together in the discussion.

Unirrigated Experiment: No significant effect on yield was found among the four herbicides tested, nor among the various rates used. Pre-emergence plots which received late cultivation yielded far more than pre-emergence plots which received no cultivation (see table 1). Plots which received no herbicide, but were normally cultivated all season, yielded significantly more than those receiving herbicides and late cultivation. Hand hoed plots yielded essentially the same as normally cultivated plots (table 1).

Table 1. The effects of different levels of cultivation and pre-emergence treatments on the yield of U. S. No. 1 potatoes with no irrigation.

	Bushels per acre
Pre-emergence	178
Pre-emergence plus late cultivation	330 *
Normal cultivation	430 +
Hand hoeing	426

* Greater than pre-emergence at odds 999:1.
+ Greater than late cultivation at odds 999:1.

Irrigated Experiment: Although no significant difference was found among the rates of application of the various herbicides, there were differences in yield associated with the herbicides themselves (see table 2). Premerge and T.C.A. produced larger yields than E. H. No. 1, and E. H. No. 2 was intermediate. It was noted on June 6, that Premerge controlled weeds the best, with T.C.A. next, and E. H. No. 1 and No. 2 had the least control. None of the chemicals, however, controlled weeds satisfactorily. Annual grasses comprised the worst problem.

Late cultivation of pre-emergence plots increased the yield markedly compared to similar plots which were left uncultivated. Normal cultivation produced a larger yield than late cultivation, but there was no significant difference between normal cultivation and hand hoeing (see table 3).

Table 2. Effect of pre-emergence herbicides on the yield of U. S. No. 1 potatoes.

	Bushels per acre
Sodium 2,4-dichlorophenoxyethyl sulphate (E. H. No. 1)	289
Dichloral urea (E. H. No. 2)	313
Sodium trichloroacetate (T.C.A.)	336
Premerge	368
L.S.D. at odds 19:1	39
L.S.D. at odds 99:1	53

Table 3. The effects of different levels of cultivation and pre-emergence treatments on the yield of U. S. No. 1 potatoes under irrigation.

	Bushels per acre
Pre-emergence	241
Pre-emergence plus late cultivation	412 *
Normal cultivation	466 +
Hand hoeing	492

* Greater than pre-emergence at odds 999:1.
+ Greater than late cultivation at odds 999:1.

Discussion

There was only one real difference in the results from the unirrigated and the irrigated experiments; namely, no difference among chemicals in the dry experiment, whereas yield differences were found among chemicals in the irrigated test. The exact reason for this is not clear.

As it was used in this study, E. H. No. 1 was handicapped by being applied after many of the weed and grass seedlings were emerging. E. H. No. 1 is a seed toxicant and should be applied before the germination of the weed seeds. This may account for the lack of weed control with E. H. No. 1 in these experiments. Another factor which may have contributed to the generally poor weed control of all the herbicides is the heavy rain (1.95 inches) which fell less than 48 hours after application of the chemicals. If the rain did lessen the effectiveness of the weed sprays, it demonstrated what a hazard a post-treatment rain might be to a farmer.

Late cultivation, following pre-emergence, increased the yield substantially over uncultivated pre-emergence plots. This is believed to be due to the much better weed control effected by the late cultivation. Normal cultivation produced larger yields than late cultivated pre-emergence plots, probably due to the earlier and more complete control of weeds. It did not appear that the herbicides were toxic, due to the fact that high rates of chemicals were no worse than the low rates. Another point for this argument is that, although the late cultivated plots were chemically treated, these plots greatly out yielded the other chemically treated ones, indicating that herbicidal treatment was not a limiting factor.

Hand hoed plots yielded as well as those normally cultivated by tractor. In both of these cases the weeds were well controlled throughout the growing season. Potato yields seemed to be reduced according to the extent of weed competition. It didn't matter whether weeds were removed by shallow hand hoeing or by deeper tractor cultivation; both removed weed competition and produced large yields. Late cultivation removed most weed competition after June 12 from those particular pre-emergence plots, and this resulted in a large increase in yield compared to uncultivated pre-emergence plots, which remained weedy all season.

Summary

Two similar weed control experiments were conducted with Katahdin potatoes in 1950; one was irrigated and the other was not. Under irrigation, Premerge and T.C.A. produced larger yields than E. H. No. 1, and E. H. No. 2 was intermediate. No difference was found among the same chemicals in the unirrigated experiment.

The following results were the same in both the irrigated and unirrigated experiments. Late cultivation of half of the pre-emergence plots increased the yield markedly compared to the uncultivated pre-emergence plots. Normal cultivation produced larger yields than late cultivation, and hand hoed plots yielded the same as those normally cultivated. In all cases the treatment affording the best weed control also produced the largest yield. Weed competition seemed to be the largest single factor which influenced yields.

COMPARATIVE STUDIES WITH CRABGRASS HERBICIDES IN TURF[1]

Gene C. Nutter and John F. Cornman[2]

A INTRODUCTION

Since crabgrass is one of the most troublesome weed pests in turf, and because of the increased interest in crabgrass control by the public toward both new and older crabgrass herbicides, the need for a study of these materials on a comparative basis is strongly evident. To aid in meeting this need two sets of comparative herbicide trials were conducted by Cornell University during the summer of 1950. These tests were not designed for the purpose of deriving recommendations pertinent to the use of the particular materials tested, but rather were conducted for the purpose of studying the relative effectiveness of the material under comparable field conditions.

B MATERIALS AND METHODS

Ten different materials, some recently developed, some older standby's were studied in these two trials, They included:

1. Arsenic acid (Zotox)-(liquid)
2. Dichloral urea - Experimental Herbicide No. 2 -(liquid)
3. Endothal (Sodium salt of 3,6-endoxohydrophthalic acid) - (liquid)
4. Maleic Hydrazide-(liquid)
5. Milarsenite (Sodium arsenite incorporated on Milorganite)-(dry) Phenal mercuric acetate (PMA) formulations.
6. Linck wettable powder (w.p.)-(liquid)
7. Linck (w.p.)-(dry)
8. Scutl (dry)
9. Aero Cyanate Onion Spray (liquid)
10. Potassium Cyanate 25% powder (dry)

The rate of application selected for each material was determined on the basis of the manufacturers recommendations or suggestions, or on recommendations from different Experiment Stations having had experience with the material. The rates as listed in Tables I and II are stated in terms of 100% active ingredient. The experimental sites were chosen in Westchester County, in the heart of the crabgrass zone of New York State. The first set of tests was conducted at the Saxon Woods Golf Course near White Plains, the second at the Willows Country Club near Rye. To simplify presentation the experiments at the two locations will be discussed separately.

LOCATION I - SAXON WOODS GOLF COURSE

This experiment was conducted on mixed bent - bluegrass turf maintained at fairway height. Here seven materials and a check (eight treatments) were tested in a Latin Square of sixty-four, 10 X 10 foot plots. The material,rates of applications,

(1) Acknowledgement is made to the American Cyanamid Company for support of this project.

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gallonages and results for the eight treatments appear in Table I. Each treatment received three applications at approximately two week intervals beginning July 27. The weather conditions at this time were hot and somewhat dry. All applications of dry materials were made with a calibrated fertilizer spreader. The sprays were applied with a specially constructed sprayer designed for experimental work on turf (3). The dry materials were applied with commercial vermiculite in cases where a carrier was needed, while "Glim" (0.1%) was used as a wetting agent for the liquid applications.

In analyzing the experiment it was found that direct counts of the number of individual crabgrass plants per plot was very misleading. For this reason the method of analysis chosen was that of estimating the percent of total plot area covered by crabgrass. For sampling, square foot quadrats were used, two samples being taken per plot by each of two estimators. For each plot the four samples were averaged and this value used as data for later analysis. The crabgrass analysis was made on September 26, one month after the last application.

Since injury to the permanent grasses is an important criterion in the evaluation of herbicides for turf, discoloration ratings were made for each plot. The discoloration ratings ranged from 1 - 15, with the higher numerical order indicating greater injury to the permanent grasses. These ratings were made three days after the last application and again one month later. The sampling procedure was the same as for the crabgrass analysis.

LOCATION II - WILLOWS COUNTRY CLUB

This experiment was also conducted on an area of mixed bent - bluegrass turf maintained under fairway conditions. Ten materials were applied in 21 treatments (Table II). Commercial vermiculite was used when needed as a carrier for the dry applications (Treatment 3, 4, 7 and 8) and a wetting agent ("Glim"-0.1%) was used for all liquid applications. Each treatment received two applications at weekly intervals beginning August 18. The materials were applied in the same manner and with the same equipment as at the first location. The weather at the time of this experiment was cooler than during the tests at Saxon Woods and the grasses were growing more vigorously.

Since space was limited in this area and since the experiment was designed in part for demonstration purposes with simplicity as the objective, similar treatments were grouped together. Each treatment was duplicated so that a replicated non-randomized block design resulted. The plots were 10 X 20 feet with a 10 foot check strip extending between the blocks and around the perimeter of the entire experimental area.

The sampling procedure was the same here as for Location I with the exception that for each sample taken within the plot a corresponding sample was obtained from the adjacent check strip. By this method it was possible to analyze the data in terms of percent reduction in crabgrass for each plot from a corresponding check, thus reducing some of the variation which would have occurred through lack of treatment randomization. The

TABLE I

RESULTS OF COMPARATIVE CRABGRASS HERBICIDAL TESTS AT SAXON WOODS GOLF COURSE

Treatment Number	Material	Rate Gallonage	% of Area Covered by Crabgrass	Actual % Reduction from Check	Discoloration Rating
I	Maleic Hydrazide	0.25%/100	85.44	0+	3.21-10.0
II	PMA-liquid	0.20oz/M*/200	39.26	43%	1.75
III	KOCN	12#/A/100	43.21	37%	4.89
IV	PMA-Scutl (2X)	0.77 oz/M -	8.9	87%	1.41
V	PMA-Linck wp-dry (2X)	1.52 oz/M -	6.9	90%	2.79
VI	Milarsenite	5#/M -	45.63	34%	4.21
VII	Arsenic Acid (Zotox)	2.00 oz/M/200	4.78	94%	15.00
VIII	Check	-	69.09	-	1.00
	LSD_{05}		17.4		1.78
	LSD_{01}		23.2		2.38

* M = 1,000 square feet

Application Schedule:
- 1st application - July 27
- 2nd application - Aug. 9
- 3rd application - Aug. 26

\+ a 24% increase in crabgrass stand occurred

Analysis Schedule:
- Discoloration analysis - Aug. 29
- Crabgrass analysis - Sept. 26

TABLE II

RESULTS OF COMPARATIVE CRABGRASS HERBICIDAL TESTS AT WILLOWS COUNTRY CLUB

Treatment Number	Material	Rate	Gallonage gal/A	Average % Control	Discoloration Rating
1	KOCN - liquid	8#/A	100	85.1	2.2
2	" - "	16#/A	100	91.5	3.8
3	KOCN - 25% Dust	8#/A	-	55.2	1.7
4	" " "	16#/A	-	52.9	5.4
5	PMA-Linck wp-liquid	0.20oz/M	100	0.	1.0
6	" " " "	0.30oz/M	100	35.9	1.0
7	PMA-Linck wp-liquid	2.00oz/M	100	94.1	4.3
8	" " " "	3.00oz/M	100	98.2	4.4
9	PMA-Linck wp-dry(1X)	0.76oz/M	-	94.2	3.4
10	" " " " (2X)	1.52oz/M	-	97.6	3.3
11	PMA-Scutl (1X)-dry	0.38oz/M	-	97.3	1.4
12	" " (2X)- "	0.77oz/M	-	99.4	2.4
13	" " (4X)- "	1.54oz/M	-	97.6	3.3
14	Arsenic Acid (Zotox)	2.00oz/M	200	99.5	13.3
15	" "	3.00oz/M	200	100.0	14.8
16	Milarsenite (dry)	5#/M	-	60.9	8.4
17	Maleic Hydrazide	0.5%	100	28.3	1.5-10
18	Endothal	8#/A	100	35.0	10.9
19	"	16#/A	100	35.4	10.3
20	Dichloral Urea	15#/A	100	93.7	1.6
21	" "	30#/A	100	100.0	1.2
	LSD_{05}			5.47	0.91
	LSD_{01}			7.44	1.24

Application Schedule:
1st application - August 18, 2nd application - August 26
Analysis Schedule:
Discoration analysis - August 29, Crabgrass analysis - Sept. 9

discoloration ratings were made in the same manner as in Location I.

C RESULTS

Both the crabgrass and discoloration data for each location were subjected to the type of analysis best fitted to the field design used. For Location I, the analysis of variance for the Latin Square design was used, while the analysis of variance for a non-randomized replicated block was applied to the data from Location II. The results of the analysis for each location appear in Table I and Table II respectively.

Location I

The treatments in this experiment fall into three groups on the basis of the results indicated in Table I. Treatment IV, PMA (Scutl) with 87% reduction in crabgrass; Treatment V, PMA (Linck w.p. - applied dry) with 90% reduction, and Treatment VII, arsenic acid (Zotox) with 94% reduction fall in one group. While there is no significant difference between these treatments statistically, a choice made on the basis of reduction in crabgrass stand alone would favor arsenic acid. However, on the basis of discoloration rating the extreme injury caused to the turf would completely rule out the use of this material at the concentration used in this experiment. This would leave Treatments IV and V - both organic mercury compounds, both applied in dry form - as the most effective treatments in this experiment based on the criteria in Table I. The second group would include Treatment II, III, and VI. The discoloration rating of these materials would not prohibit their use, but they did not give satisfactory control of crabgrass under the conditions of this experiment. The third group would include Treatment I - maleic hydrazide in which an increase occurred in the percent of crabgrass. The initial discoloration analysis for this material showed little injury to the permanent grasses, however later examination disclosed that the grasses were slowly dying and that within a month they were dead.

Location II

With respect to the effective kill of crabgrass, arsenic acid, the organic mercuries (Scutl and Linck w.p.), dichloral urea, and KOCN (liquid) all gave excellent control of crabgrass. The other materials tested did not give satisfactory results and hence will not be discussed further in this paper. From the standpoint of discoloration, these materials were quite satisfactory with the exception of arsenic acid. At this location, as at Location I, the sever injury to the turf would rule out arsenic acid as a selective herbicide at the concentration used.

D DISCUSSION

In the over-all consideration of the experiments at both locations a number of facts are pertinent:

1. In general, comparable treatments reacted similarly in both locations with the exception of KOCN which gave much better results in the later tests with respect to both

crabgrass control and discoloration. (The liquid mercury treatments cannot be compared at the two locations because different materials were used). This increased effectiveness when used later in the season (near or after mid-August) is characteristic of KOCN and has been observed in field tests at Cornell University in both 1949(4) and 1950. It is believed to be correlated with soil moisture, temperature and the growing condition of both the turf and the weed pest.

2. In all cases comparable treatments gave a higher percent reduction in crabgrass in the later tests with two applications than with three applications earlier. The shorter treatment interval is partly responsible for this difference, but more important is the timing factor. Crabgrass enters into the declining phase of its growth cycle in the latter part of the summer and is hereby more susceptible to treatment. Conversely, the permanent grasses are entering into a period of more active growth and are able to recover faster from chemical treatment.

3. In general, where both liquid and dry applications of the same materials were tested, less discoloration resulted from the dry form. The exception to this is the higher rate of KOCN dry powder in which a separation between the active ingredient and the carrier may have occurred.

4. Both the mercury and the dichloral urea treatments were much slower in rate of action than were the KOCN and arsenic acid treatments. In the case of the two latter materials the effect of the treatments could be seen almost immediately, whereas the maximum effect of the dry mercury applications and dichloral urea was not apparent for two to three weeks. The failure to recognize this slowness of action has been the cause of dissatisfaction among some users of the dry mercury formulations.

In the final analysis, the practical evaluation of herbicides for turf should be based upon four criteria:

1. The effective kill of crabgrass
2. The amount of discoloration or injury to the turf
3. The cost and availability of the formulated product
4. The ease and safety of handling

While the first two criteria are most important and have been the subject of these tests, the third and fourth may be the factors which ultimately decide the choice of the material to be used.

On the basis of the first two criteria, already discussed, the dry mercuries, KOCN and dichloral urea proved to be the best material. Both DeFrance (1) and Engle (2) have reported good results with liquid mercury applications, but because of the somewhat variable results with these materials in this set of experiments, comment is with-held pending further testing. On the basis of cost and availability further restrictions may be imposed. While costs are subject to variation, at the time of analysis the general ranking of the above materials was (in order of increasing cost) arsenic acid or sodium arsenite, liquid KOCN (Aero-Cyanate Onion Spray - the rank may shift if compared on the basis of formulated products), Linck w.p. and Scutl. The size of the area to be treated enters into the cost aspect. While, for home lawns and comparable small areas the cost of Scutl may not be prohibitive, when considered for large areas the cost will limit its use. All of the most promising materials are available on the market with the exception of dichloral urea.

From the standpoint of toxicity to handlers and other warm blooded animals the arsenicals and the mercuries must be handled with care. Potassium Cyanate and dichloral urea are not hazardous when treated with ordinary caution. As to ease of handling for dry materials Scutl is sold ready for immediate application while both Linck's PMA w.p. and KOCN dry powder must have a carrier or diluent added. For liquid application, the flake form of KOCN is readily soluble and easy to handle, Linck's w. p. is quite satisfactory, while the formulation of dichloral urea used was only slightly soluble and bulky.

TABLE III

SUMMARY FOR THE EVALUATION OF 10 MATERIALS TESTED AT LOCATION II

Material	Effective Crabgrass Control	Discoloration Rating	Relative Cost	Availability	Toxicity	Ease of Handling
Arsenic Acid	v. good	v. high	v. low	good	hazardous	must be handled carefully
Dichloral urea	v. good	v. low	?	?	low	bulky
Endothal	poor	high	?	?	requires caution	pungent odor
Maleic Hydrazide	v. poor	high	?	?	?	fair
Milarsenite	poor	medium to high	moderate	fair	requires caution	good
Linck-PMA wp (liq)	variable	moderate	"	good	may be hazardous	good
Linck-PMA wp (dry)	v. good	low to medium	"	good	"	requires carrier
Scutl-PMA (dry)	v. good	low	high	good	"	good
KOCN-liquid	v. good	moderate	low	good	requires caution	v. good
KOCN-25% powder	poor	moderate	low	good	requires caution	requires carrier

A summary of the factors which should be considered in the practical evaluation of the ten materials tested in this experiment is given in Table III. The entries in the table are based on the concentration of each material which gave the best control under the conditions at Location II.

E SUMMARY

Ten materials were compared as crabgrass herbicides for turf at two locations in Westchester County during the summer of 1950. The experiments were analyzed in terms of (1) effective crabgrass control and (2) discoloration or injury to the permanent grasses. The data was subjected to statistical analysis and the results presented in Tables I and II.

Under the conditions of this experiment the materials which performed best on the basis of these two criteria were Linck w.p. applied dry with vermiculite and Scutl, (both phenal mercuric acetate formulations - PMA), potassium cyanate and dichloral urea. The PMA formulations are effective after mid-summer. Their rate of action is slow. Potassium cyanate reacts rapidly and is most effective when used after mid-August. Dichloral urea is not available on the market.

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Three New Compounds for Controlling Crabgrass in Turf

Ralph E. Engel and Richard J. Aldrich[1]

Phenyl mercury compounds and potassium cyanate have received attention as promising chemicals for crabgrass control. These materials were tested at Rutgers University during 1948 and 1949. In addition to the mercury and cyanate chemicals, three new chemicals: monoaminoboronium fluoride (S-1840), Tris (2-hydroxypropylamino) boronium fluoride (S-1980), and Bis (lauryl, di-2-hydroxyethylamino) boronium fluoride (S-1998) have given promising results (2). All materials were again tested during the summer of 1950.

The first treatments in the 1950 test were made August 16. The second and third treatments were made on August 23 and August 30. The plots were 4 x 15 feet in size and each treatment was in triplicate. The test was on a turf (1-1/8 inch cut) predominantly Kentucky bluegrass, with some Colonial bentgrass, and Chewing's fescue present. The crabgrass plants had approached the creeping stage at the time the treatments were started. Soil moisture was low at the time of the first application. However, adequate rainfall occurred during the first week and conditions were favorable for turf throughout the test period.

Injury ratings were made October 6, at which time they were observed for lasting turf injury. The ratings were as follows:

0 = none
1 = trace
2 = moderate
3 = severe
4 = very severe.

The cool, moist weather of late August and early September did not encourage the crabgrass plants to mature. For this reason it was difficult to rate the plots for crabgrass control on the basis of general appearance. As a result, the actual number of plants per square foot were counted at four locations in each plot. The final results are given in Table II.

Conclusions

1. S-1840, S-1980 and S-1998 gave crabgrass control equivalent to that obtained with the several phenyl mercury compounds and with potassium cyanate. Essentially no injury was evident 36 days after treatment.

2. The S-1840, S-1980 and S-1998 treated plots were superior to the sodium arsenite treatments used in this test.

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[1] Research Associate, Farm Crops Dept., Rutgers University and Agent, USDA, BPIS&AE, Division of Weed Investigations, respectively.

[2] References in 1949 and 1950 NEWCC Proceedings.

Table I. Identity of materials tested.

Chemical	Common Designation	Percent Active Ingredient %	Phenyl mercury acetate equivalent per plant
Sodium arsenite	sodium arsenite WA[1]	90.7	----
" "	sodium arsenite	90.7	----
Phenyl mercuric-acetate	PMAS	10.4	0.458
Phenyl mercuric-acetate	C-Lect	5.2	0.456
Phenyl mercuric triethanol ammonium lactate	Puraturf CK	2.2	0.458
Phenyl mercuric monoethanol ammonium acetate	Seltox	2.3	0.460
Potassium cyanate	Potassium cyanate[2]	91	-----
Monoaminoboronium fluoride	S-1840[2]	100	-----
Tris (2-hydroxypropylamino) boronium fluoride	S-1980	75	-----
Bis (lauryl, di-2-hydroxyethylamino) boronium fluoride	S-1998	75	-----

[1] Triton X-100 used at a concentration of 0.25%.
[2] These materials were prepared with wetting agents.

Table II. Comparative performance of several chemicals for crabgrass control. August, 1950.

	Material	Rate of[1] concentrate per acre	No. of applications	Av. No. crabgrass plants/ sq. ft.[2]	Permanent[3] Injury
1	Sodium arsenite WA[4]	2.5 lbs.	3	0	2.3
2.	Sodium arsenite	2.5 lbs.	3	10.3	1.0
4.	PMAS (10.4%)	3.4 qts.	3	0.2	0.2
7.	C-Lect (5.18%)	6.8 qts.	3	0	0
9	Puraturf CK (2.18%)	16.1 qts.	3	0.3	0
11	Seltox (2.3%)	15.3 qts.	3	0.4	0
18	Potassium cyanate WA	8 lbs.	3	3.1	0
19	Potassium cyanate WA	12 lbs.	3	0.5	0
20	Potassium cyanate WA	16 lbs.	3	0	0.5
23	S-1840 WA	20 lbs.	3	0	0.5
24	S-1840 WA	30 lbs.	3	1.1	0.7
28	S-1980	4 gal.	3	0.2	0
29	S-1998	6 gal.	3	1.5	0.7
30	S-1998	4 gal.	3	2.3	0.2
	Check	-----	-	22.8	---
	L.S.D. .05	-----	-	4.0	----

[1]Sodium arsenite, potassium cyanate, and S-1840 are given on basis of active ingredient. The rest are given on the basis of prepared concentrate. All solutions were diluted to 360 gallons/acre for application.

[2]The figures given represent the average of three plots. On each plot, the number of crabgrass plants were determined for four random samples of one square foot each.

[3]Injury ratings were estimated (October 6, 1950) on the basis of: (0) none; (1) trace; (2) moderate; (3) severe; and (4) very severe. Note: these are based on enduring injury and are not necessarily an indication of temporary discoloration.

[4]WA indicates the use of a wetting agent.

Potassium Cyanate, P.M.A.S. and Maleic Hydrazide in the Control of Crabgrass

by

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Crabgrass (Digitaria sp.) is a troublesome weed in lawns in parts of Eastern Canada, particularly in south-western Ontario. Chemical control of this weed has been studied for the past two seasons in lawn plot tests at the Ontario Agricultural College, at Guelph.

The area chosen for crabgrass tests consisted of a weakened stand of Kentucky blue grass with a small quantity of bent grass. Crabgrass, dandelions, common plantain, ribgrass and other weeds were well distributed over the lawn.

Methods

In 1949 phenyl mercuric acetate (P.M.A.S.) was applied at 3 oz. of Tat-C-Lect (1.2% Hg)/3 Imperial gallons (3.6 American) of water/square rod in 1, 2 or 3 treatments. Potassium cyanate (Cyanate) was tested at 1.6 oz. of Aero Cyanate (91% KCNO)/gal./square rod, both with and without sticker. Treatments were made on triplicate half square rod plots arranged at random over the plot area. Percentage of the vegetation crabgrass, and the effect of the chemicals on the lawn grasses were estimated.

In 1950 the experiment was enlarged to cover a wider range of treatments. P.M.A.S. (Tat-C-Lect 1.2% Hg) was tested both with and without 2,4-D at 3 oz./2 Imperial gallons (2.4 American)/square rod. Where 2,4-D was required 225 p.p.m. of 2,4-D acid as the triethanolanine salt (Tat Weed C-Lect) was used. One, two or three applications per plot were made. The crabgrass at the time of the initial treatment (7 July) was in the three leaf stage.

The 1950 test with potassium cyanate (91% Aero Cyanate) consisted of 1 and 2 treatments at 3 different concentrations, with or without sticker (Spraylastic 10 ml./3 gal.). The chemical was dissolved in water and 2 Imperial gallons (2.4 American) applied per square rod. The heaviest concentration was applied both with a sprayer and with a fine rose sprinkling can. The initial treatment was made 2-4 August at which time the crabgrass was in the advanced seedling--pre-heading stage. Maleic hydrazide was applied as 1, 2 or 3 treatments at 1 or 2 lb. of pure chemical per acre. Solutions of the chemical were applied at 2 gal./square rod with a sticker (Spraylastic 10 ml./3 gal.) added for the second and third treatments. The initial treatment was made 4 August.

Except where noted above the chemicals were applied with a high volume sprayer on triplicate half square rod plots randomized over the lawn area. The P.M.A.S. treatments were made in one block and the potassium cyanate and maleic hydrazide series in a second.

Generally the 1949 season was characterized by hot, dry weather, while the 1950 season was cool and moist. No artificial watering or fertilizer (other than in the herbicides) was applied and normal lawn mowing operations were practised.

Table 1. The effect of P.M.A.S. and P.M.A.S. plus 2,4-D on crabgrass and other weeds in lawns. Crabgrass initially at the three-leaf stage. Guelph, 1950.

Treatment	Treated	Notes 28 July, 1950[x]			Estimated % [xx] of vegetation crabgrass 28 Sept. 1950
		Crabgrass	Plantains & Dandelions	Lawn Grass	
P.M.A.S. 3 oz./2 gal./ square rod (.036 oz. of Hg/sq. rod)	7 July	1	0	1	22
		2	0	2	14
		3	1	1	19
					Av. 18
	7 & 19 July	2	1	2	9
		2	1	2	3
		2	1	2	9
					Av. 7
	7, 19 & 29 July	3	1	2	2
		3	1	2	3
		3	1	1	0
					Av. 2
P.M.A.S. 3 oz./2 gal./ square rod with 225 p.p.m. of 2,4-D	7 July	2	3	1	22
		2	2	2	15
		3	3	2	11
					Av. 16
	7, 19 & 29 July	4	3	3	0
		2	3	3	2
		3	3	3	2
					Av. 1
Checks	-	0	0	0	34
		0	0	0	61
		0	0	0	57
					Av. 51

[x] 0 = no effect 1 = slight 2 = moderate 3 = severe 4 = very severe

[xx] Figure for each plot is the average of estimates of 9 single square foot quadrats.

Results

The results of the 1949 test have been reported previously[1]. Essentially the results showed that P.M.A.S. at 3 oz./3 gal./square rod gave good control of crabgrass if more than one treatment was

[1] Proceedings of the Sixth Annual North Central Weed Control Conferences, page 206, 1949.

applied. A single treatment was not satisfactory when applied at the 3 leaf stage or just previous to heading. Single treatments of 1.6 oz. of 91% cyanate (0.9% or 1.5 oz. of KCNO)/square rod gave a quick kill of crabgrass seedlings, and also a severe burn of the lawn grass. The grass, however, recovered in about 10 days. Vatsol K added to the potassium cyanate did not alter the results at the concentrations used. In general, the cyanate plots deteriorated somewhat in early September indicating that more than one treatment would have been desirable. However, because of the severe effect of the initial treatment on the lawn grass a second one was not made. Preliminary trials suggested the possibility of effective crabgrass control by more than one treatment at lower concentrations.

The 1950 results with P.M.A.S. presented in Table 1 support the 1949 findings and show that more than one treatment of this chemical is needed for effective crabgrass control. The addition of 2,4-D had little effect on the ultimate crabgrass control, but gave good control of plantains and dandelions. Most of the treatments yellowed the lawn grass for a period of time. The three treatments of P.M.A.S. plus 2,4-D had a marked effect on the lawn grass for several weeks.

The following observations may be made from the results of the Cyanate tests presented in Table 2:

1. Two treatments gave a more consistent control of crabgrass, especially at the lower concentrations.
2. At the concentrations and volumes used in this test, the presence or absence of a sticker (Spraylastic 10 ml./3 gal.) failed to influence the results either with respect to kill of crabgrass or injury to lawn grass.
3. All concentrations, except the .2 percent, gave a marked burn to the lawn grass. This burn, however, was of a temporary nature and disappeared with the growth of new grass.
4. While the .2 percent potassium cyanate gave unsatisfactory control of crabgrass with a single treatment, two treatments at this concentration gave good control with only a small degree of burning to the lawn grass.
5. The heavy concentration reacted in a similar manner whether applied with a sprayer or a fine rose sprinkling can. The results suggest a further investigation of application with a sprinkling can at lower concentrations of cyanate.

The results in Table 3 show that maleic hydrazide when applied at the pre-heading stage of crabgrass failed to effectively control this weed. No explanation is offered for the increase in percentage of crabgrass from the three treatments. Notes taken on these series of plots are of interest and may be summarized as follows:

4 August - Initial treatments at 1 and 2 lb. of maleic hydrazide per acre without sticker.

Table 2. Effect of potassium cyanate treatments on crabgrass in lawns. Crabgrass initially at advanced seedling to pre-heading stage. Guelph, 1950.

Treatments	Oz. KCNO per sq. rod per treatment	% KCNO (2 gal.)	Sticker[x]	Effect of chemical on lawn grass[xx] 7 dys.	26 Sept.	Notes Sept. 28,1950 Crabgrass % of vegetation[xxx]	Estimated over-all crabgrass control
2-4 Aug. (one)	.64	.2	+	1	0	20	50
			+	2	0	11	50
			+	1	0	10	40
"	1.28	.4	+	1	0	13	50
			+	3	1	4	90
			+	3	1	10	95
"	2.56	.8	+	3	0	3	80
			+	4	0	0	95
			+	4	2	0	95
" (Sprinkler)	2.56	.8	+	3	0	2	75
			+	4	0	3	95
			+	4	1	2	95
"	.64	.2	-	1	0	1	40
			-	2	0	5	90
			-	1	0	6	50
"	1.28	.4	-	3	0	1	95
			-	2	0	7	90
			-	3	0	1	95
"	2.56	.8	-	1	0	0	60
			-	4	1	2	95
			-	4	1	0	90
" (Sprinkler)	2.56	.8	-	3	0	3	75
			-	4	1	5	95
			-	4	1	1	90
2-4 Aug. & 11 Aug. (two)	.64	.2	+	1	0	3	40
			+	2	0	4	90
			+	2	0	3	95
"	1.28	.4	+	2	0	1	80
			+	4	1	0	95
			+	3	1	1	100
"	2.56	.8	+	4	2	0	95
			+	4	2	0	100
			+	4	2	0	100

" (Sprink-ler)	2.56	.8	+	4	1	0	95
			+	4	1	0	100
			+	4	2	0	100
"	.64	.2	-	1	0	2	90
			-	2	0	2	90
			-	2	1	2	90
"	1.28	.4	-	3	0	0	90
			-	3	0	0	100
			-	3	0	1	100
"	2.56	.8	-	4	1	0	100
			-	4	2	0	100
			-	3	1	0	100
" (Sprink-ler)	2.56	.8	-	4	1	2	100
			-	4	0	0	100
			-	4	2	0	100
Checks	-	-	-	-	-	53	-
			-	-	-	24	-
			-	-	-	24	-
			-	-	-	23	-
			-	-	-	26	-
			-	-	-	46	-

x Sticker, Spraylastic 10 ml./3 gals.
xx 0 = no effect 1 = slight 2 = moderate 3 = severe 4 = very severe
xxx Figure for each plot is the average of estimates of 9 single square foot quadrats.

Table 3. The effect of maleic hydrazide on the control of crabgrass when applied at the pre-heading stage. Guelph, 1950.

Treatment	Rate/acre	Notes 28 September, 1950 Effect on Lawn Grass[x]			Crabgrass % of vegetation[xx]		
4 August (one)	1 lb.	1	1	1	39	34	42
	2 lb.	2	2	2	36	31	33
4 August 15 August 22 August (three)	1 lb.	1	2-3	3	49	47	64
	2 lb.	4	4	4	66	68	72
Check	-	0	0	0	23	26	46

x 0 = no effect 1 = slight 2 = moderate 3 = severe 4 = very severe
xx Figure for each plot is the average of estimates of 9 single square foot quadrats.

11 August - No effects noticeable
15 August - Second treatment made on half the plots
22 August - No effects noticeable. Third treatments made
7 Sept. - 2# 3 treatment had a close cropped appearance
1# 1 treatment had slight effect
15 Sept. - Crabgrass, Kentucky blue grass and white dutch clover all retarded in growth on those over 1#/acre
25 Sept. - As 15 Sept., but crabgrass purplish brown.
17 Oct. - Effects still noted on the lawn grass and clover on 2#/acre - 3 treatment plots.

Summary

1. P.M.A.S. at 3 oz./3 gal./sq. rod gave a good control of crabgrass if more than one treatment was applied. Generally effective treatments yellowed the lawn for a period of time. 2,4-D added to the P.M.A.S. controlled several broad leaved species. Three treatments of the mixture was hard on the lawn grass.
2. Two treatments with 2 gal. of 0.2 percent potassium cyanate gave good control of crabgrass with only a minor burn to the lawn grass. At the concentrations used a sticker did not affect the results appreciably.
3. Maleic hydrazide was non-effective for crabgrass control when applied at the pre-heading stage. Effects on lawn vegetation were noted.

FACTORS ALTERING THE EFFECTIVENESS OF POTASSIUM CYANATE FOR CRABGRASS CONTROL

R. H. Beatty and B. H. Davis[1]

INTRODUCTION:

Potassium cyanate was disclosed in 1949 (1) as an outstanding chemical for the selective control of crabgrass (Digitaria sanguinalis) in turf, and further work was reported to this Conference in 1950 (2), (3). During the summer of 1950, experiments were run to investigate possible causes and remedies for the irregular results occasionally observed in field work. Factors investigated included (a) temperature of the solution, (b) number of applications, (c) degree of concentration, (d) rate of wetting agent, (e) type of wetting agent, (f) possible activators, and (g) spray particle size.

METHOD:

The first two series of tests were conducted on private lawns with heavy and uniform infestations of crabgrass. The main experimental site was the practice fairway of the Philadelphia Country Club[2] which was also heavily and uniformly infested with crabgrass. All plots were 100 feet square, and at the country club were replicated three times. Check plots were included in all tests. A knapsack sprayer with a fan-shape nozzle discharging 16 gallons of solution per hour at 15 pounds pressure was used for treatment. Applications were at the rate of 100 gallons of water per acre, and each plot was covered three times at approximately 4 miles per hour to insure as even and complete coverage as possible. Through most of the testing season temperatures were moderate and soil moisture adequate.

DISCUSSION OF INDIVIDUAL TESTS:

Temperature of the solution: The first tests were made May 25 when crabgrass kill had been rather slow, apparently because of prolonged cool weather. Weedone Crabgrass Killer was applied at the rate of 8 and 16 lbs/A of KOCN, using hot (180° F.) and cold (60° F.) water for making the solution. Two types of sprayer were used in this test -- the regular knapsack sprayer, and an inexpensive plastic gravity flow nozzle designed to be attached to a glass jug. The crabgrass plants were in the two-leaf stage. The best kill resulted from applying 16 lbs/A KOCN in hot water with the knapsack sprayer, followed by 16 lbs/A applied in hot water with the plastic sprayer. The 8 lbs/A rates followed the same trend, indicating a possible advantage to using hot water at this time of year, and an advantage to using the finer spray under pressure.

Number of applications: Tests of the effect of cumulative applications of Weedone Crabgrass Killer were begun June 23, with applications at

[1] Agr. Chem. Div. Research Dept., American Chemical Paint Co., Ambler, Pa.
[2] Appreciation is extended to Marshall E. Farnham, Superintendent, who made the site available, and gave helpful suggestions and criticisms.

the rate of 8 lbs/A KOCN repeated at three-day intervals to all but one of the plots sprayed on the previous date. It was intended that the 16 lbs/A KOCN should receive similar cumulative applications, but discoloration of permanent grasses from a single application was severe enough that no more than two applications were made to the 16 lbs/A plots. Four applications of 8 lbs/A produced 100% control which persisted throughout the season, the last observation being made August 19. 8 lbs/A applied three times gave nearly as good control, with slight reinfestation as the season progressed. There was an increasing amount of reinfestation in the other plots.

Degree of concentration: Weedone Crabgrass Killer was applied July 21 at rates of 4, 6 and 8 lbs/A KOCN with duplicate applications being made at intervals of 3, 6 and 9 days. Best results were obtained by repeating the 8 lbs/A in 9 days. No 4 lbs/A application gave acceptable results. The 6 lbs/A applications were less satisfactory than the 8 lbs/A treatments.

Rate of wetting agent: It was observed during tests that the crabgrass blades were not thoroughly wetted by application of the spray, and at the Phila. C. C. a series of tests was made to investigate this factor. Replicated plots were laid down July 21 with straight potassium cyanate (no wetting agent), and with KOCN combined with Igepon at the rates of 1.6, 0.8, 0.4, and 0.2 lbs/A. Plots treated with KOCN plus Igepon showed slightly better control of crabgrass than the plots treated with KOCN alone, but there was no apparent difference between the different rates of Igepon used.

Type of wetting agent: Since no difference appeared between rates of wetting agent used, on August 1 different types of wetting agents were tested to see if better wetting and possibly more uniform results could be obtained. One cationic, one nonionic, and three anionic wetting agents were combined with KOCN and compared to treatment with KOCN alone. Again, no difference in performance was detected, although some wetted the crabgrass blades considerably better than others.

Possible activators: Ammonium sulfate applied July 21 had no apparent effect, either alone or in combination with KOCN and Igepon.

KOCN was applied August 4 at rates of 8 and 16 lbs/A alone and in combination with 2,4-D sodium salt at rates of ½ and 1 lb/A 2,4-D acid equivalent. These treatments were repeated on half of the plots August 15. Plots were replicated three times. The unlabelled plots were rated four times after treatment, the last time on September 7. The best control of crabgrass was obtained with 16 lbs/A KOCN plus 1 lb/A 2,4-D applied twice. However, as was observed with other 16 lbs/A treatments during the season, there was considerable discoloration of desirable grasses. 8 lbs/A KOCN plus ½ lb/A 2,4-D applied twice produced nearly as good control and much less discoloration. As has been mentioned previously, areas receiving double applications showed considerably better control than those receiving only one application, whether at the 8 lbs/A rate or the 16 lbs/A rate. All treatments incorporating 2,4-D controlled broadleaf weeds (mainly plantains and dandelions) satisfactorily.

Spray particle size: Results from using different size spray particles were compared in tests started September 6, the applicators ranging from a common watering can to a knapsack sprayer fitted with a mist nozzle.

The watering can was ineffectual as an applicator; an operator must practically run to apply the solution at the 300 gal/A rate, and coverage is very poor. The plastic jug-type gravity sprayer was only slightly better. Best results were obtained with the mist nozzle (Monarch F-97 2.0) which discharged 2 gal/hour at 100 pounds pressure. Coverage with this was excellent, but the excessive amount of time required for this kind of application did not seem justifiable. A nozzle applying approximately 20 gal/hour at 100 lbs. pressure (Monarch F-97-S 20.0) seemed most advisable from the standpoint of getting thorough coverage (which appears essential with this contact-killing chemical) in a reasonable length of time.

CONCLUSIONS FROM TESTS:

Under the conditions of these experiments, it was concluded that

(a) a hot solution of KOCN was more effective than a cold solution in early spring;
(b) there was comparatively little benefit from a single application of 8 or 16 lbs/A KOCN; two, three and four applications of 8 lbs/A gave increasingly better results;
(c) 8 lbs/A KOCN produced a satisfactory kill of crabgrass with little discoloration of turf grasses; 16 lbs/A killed crabgrass somewhat better but discolored turf grasses considerably more; 6 lbs/A was less satisfactory than 8 lbs/A; no 4 lbs/A treatment gave acceptable results;
(d) there was a slight advantage to using a wetting agent with KOCN. The types and amounts tested appeared to be unimportant.
(e) There was an advantage to combining 2,4-D with KOCN for crabgrass control.
(f) A fairly fine spray gave best results. A watering can is not appropriate for making KOCN treatments. Thorough coverage and uniform distribution of KOCN over the prescribed area appears essential to its successful use.

GENERAL CONCLUSIONS:

From general observations during the season, it was also concluded that:

(a) Even though crabgrass was not completely killed, it was thinned out so that permanent grasses either were not crowded out, or were able to re-establish themselves. Such crabgrass was stunted, did not appear to develop further, and did not set seed. Lawn seed sown on treated spots, even when crabgrass was not raked out, germinated and overcame crabgrass remaining.
(b) Permanent grasses injured by mid-summer treatment were slow to recover. Results with KOCN at that time were erratic. Mid-summer treatment does not seem advisable; rather, late spring and early fall treatments. Recovery seldom began sooner than a week after treatment. No treatment of 8 or 16 lbs/A produced permanent injury of consequence.
(c) Retreatment should be made when crabgrass starts to grow again, usually in about a week.

Several of these tests will be repeated or expanded during the coming season, and other factors will be tested for possible significance.

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The Use of Repellents in Reducing the Hazards of Poisoning by Sodium Arsenite[1]

Robert E. Frans and Richard J. Aldrich[2]

Sodium arsenite has been known for many years as an effective herbicide and soil sterilant. However, a factor that has reduced its usefulness is its poisonous effect on livestock. Consequently, the New Jersey Agricultural Experiment Station has been studying the use of repellents, as related to keeping livestock from grazing arsenite-sprayed land where they may have access to such land.

The first material used in these studies was Zinc dimethyl-dithio-carbamate-cyclohexylamine complex (trade name z.a.c.), a deer repellent manufactured by the B. F. Goodrich Chemical Company. z.a.c. is a white organic solid which makes a suspension in water. It has been successfully used to repel deer in areas where they have caused considerable crop damage. The object of the work reported here was to study the possibility of using z.a.c. to repel cows from sodium arsenite-treated areas and keep them from consuming a toxic quantity of forage.

Three 1/9-acre plots were fenced off within a meadow and sprayed with sodium arsenite at the rates of 0, 5, and 10 lbs./acre respectively. All three plots were then sprayed with z.a.c. deer repellent at 40 lbs./acre. Two Jersey cows used in this experiment were fed hay before they were allowed to enter the treated areas. A salt lick was also provided to overcome the cow's natural affinity to the salty taste of sodium arsenite.

The treated plots were opened to the cows one at a time on three successive days, and on the fourth day all the plots were left open to them. When the cows first entered the treated areas they tended to just smell the grass and move on within the area. After being in the areas a short time they took a few bites of the grass. However, they soon developed a distaste for the grass and moved to the fence lines or untreated areas to graze. The animals were not prevented from grazing the treated plots, but at no time did they show any harmful effects from what little they did graze.

In the second experiment involving the use of repellents, z.i.p. was used in place of z.a.c. z.i.p. is also manufactured by the B. F. Goodrich Chemical Company and differs from z.a.c. only in having an adhesive added.

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[1]Acknowledgment is made to the American Smelting and Refining Company for their support of this project and to the B. F. Goodrich Chemical Company for supplying materials.

[2]Research Assistant, Farm Crops Dept., Rutgers University, and Agent, USDA, BPIS&AE, Division of Weed Investigations, respectively.

In this test an area 225 ft. by 36 ft (approximately 1/5 an acre) was first sprayed with sodium arsenite at the rate of 85 lbs./acre. A 20 lbs./acre application of z.i.p. was applied immediately following the arsenite treatment. As in the first test, two Jersey cows were given access to the treated area on three successive days and their actions carefully noted.

The cows did not enter the area voluntarily the first day but had to be driven in. However, they did not graze. On all three days the animals showed the same tendencies as in the first experiment -- that is, a lack of interest in grazing the treated grass, and an apparent distaste for the grass when an occasional bite was taken.

It would seem then, that in these two experiments, both the z.a.c. and the z.i.p. were effective in repelling the cows. In the first experiment z.a.c. was used at the rate of 40 lbs./acre and in the second z.i.p. was used at the rate of 20 lbs./acre. The latter rate seemed to be just as effective as the former. z.i.p. would also seem to be the more desirable material because of its adhesive qualities.

The cattle in these experiments at no time showed any harmful effects from what little grass they consumed on the treated areas. Of course, when concentrations of sodium arsenite higher than 100 lbs./acre are used the danger of poisoning is also increased. But certainly, the cattle would be much safer in such an area that had been sprayed with the repellent than in an area that had not been sprayed.

From these experiments it would appear that the use of repellents offers a possible solution to the problem of toxicity of sodium arsenite when its use is contemplated as a herbicide or soil sterilant.

SPECIAL EQUIPMENT FOR THE APPLICATION OF HERBICIDES TO EXPERIMENTAL TURF PLOTS

Gene C. Nutter[1]

A INTRODUCTION

It is widely recognized among workers in the field of weed control that one of the most important problems in the field is the development of new and improved equipment for the application of spray materials. This problem is equally as important where herbicides are used in the field of turf. While various types of sprayers have been developed for field application of chemicals to turf, little has been done in the way of developing specialized equipment which would insure accurate apportionment and even distribution of spray materials to research plots. In an effort to improve this condition an experimental sprayer was designed and built at Cornell University in 1949 (revised in 1950) for use in conjunction with a field testing program for crabgrass herbicides in turf[2]. This paper deals with the features, design and development of this machine.

B IMPORTANT FEATURES

The requirements of the experimental work to be done necessitated that a machine be developed to meet the following objectives:

1. Adaptability for the application of herbicides to turf.
2. Accurate delivery of specific amounts of material to a given area.
3. Even distribution of material over experimental areas to be covered.
4. Capability of delivery over a wide range of volumes.
5. Adjustment and control of pressure within low pressure range - 15- to 70 pounds per square inch (p.s.i.).
6. Controlled and calibrated rate of travel.
7. Adaptability for use on plots of various sizes.
8. Good maneuverability over experimental plots.
9. Ease of operation and transportation.

Based on the method by which the spray solution is delivered from the spray tank to the nozzles, alternative types of spray systems can be used. One is the negative pressure or pump system in which a small capacity liquid pump draws the material from the tank. The second is a positive pressure system in which a pressurized gas forces the material out of the spray tank into the lines. Because it can be more accurately controlled for experimental work and is easier to manipulate, the pressurized gas system was chosen with carbon dioxide (CO_2) as the propellent gas. The important features required for this system are enumerated and discussed, Numbers in parenthesis refer to numbers on the diagram.

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[1]Turf Research Assistant, New York State College of Agriculture, Cornell University, Ithaca, New York.
[2]Acknowledgement is made to the American Cyanamid Company for financial assistance in this project.

1. Spray Tank (9).

This tank should have a capacity adequate to meet the needs of the proposed experimental work. It is usually desirable for the tank to be large enough to hold the material needed for all replicates of the same treatment. This quantity, of course, is determined by the size of plots, the number of replicates, and the gallonage range being tested. The tank must be constructed strongly enough to withstand the maximum pressure exerted on the system plus a generous safety factor. This pressure will not usually exceed 70 p.s.i. for herbicidal work.

2. CO_2 Cylinder (8).

Here again the same size limitations placed on the spray tank will apply to the CO_2 cylinder. It should have capacity enough to maintain adequate pressure for the experimental work at hand with a minimum of recharging. It is difficult to state in general terms the area that can be covered per tankfull of CO_2 because it will vary with such factors as the operating pressure, the rate of travel, the number of treatments per replicate; the number of replicates, etc. In general, an experimental design which includes many treatments and few replicates will utilize more CO_2 than a design of the same size which includes fewer treatments and more replicates. This is true because for each additional treatment the pressure head built up during the application of the previous treatment must be discharged before the spray tank can be refilled, whereas several replicates of the same treatment can be applied without discharging the pressure head. In the machine discussed, a cylinder of six pound capacity is used. Operating at pressures of 25-40 p.s.i. and traveling at approximately 2 m.p.h., as much as an acre of field plots has been applied per tankful of CO_2.

Another factor to consider is the availability of the gas. If CO_2 is used, a supply house should be nearby unless arrangements are made for recharging the supply cylinder from larger storage tanks.

3. CO_2 Shut-off Valve (6).

Most CO_2 cylinders are supplied with satisfactory shut-off valves; otherwise special valves should be placed in the line.

4. Pressure Regulating Valve (4).

This is an important feature in every well engineered spray system. If even distribution of spray material is to result, accurate control of the quantity and rate of pressure must be maintained at all times. With an accurate pressure regulating valve, this can be accomplished by merely manipulating the control until the desired pressure is registered on the influent pressure guage.

Figure 1

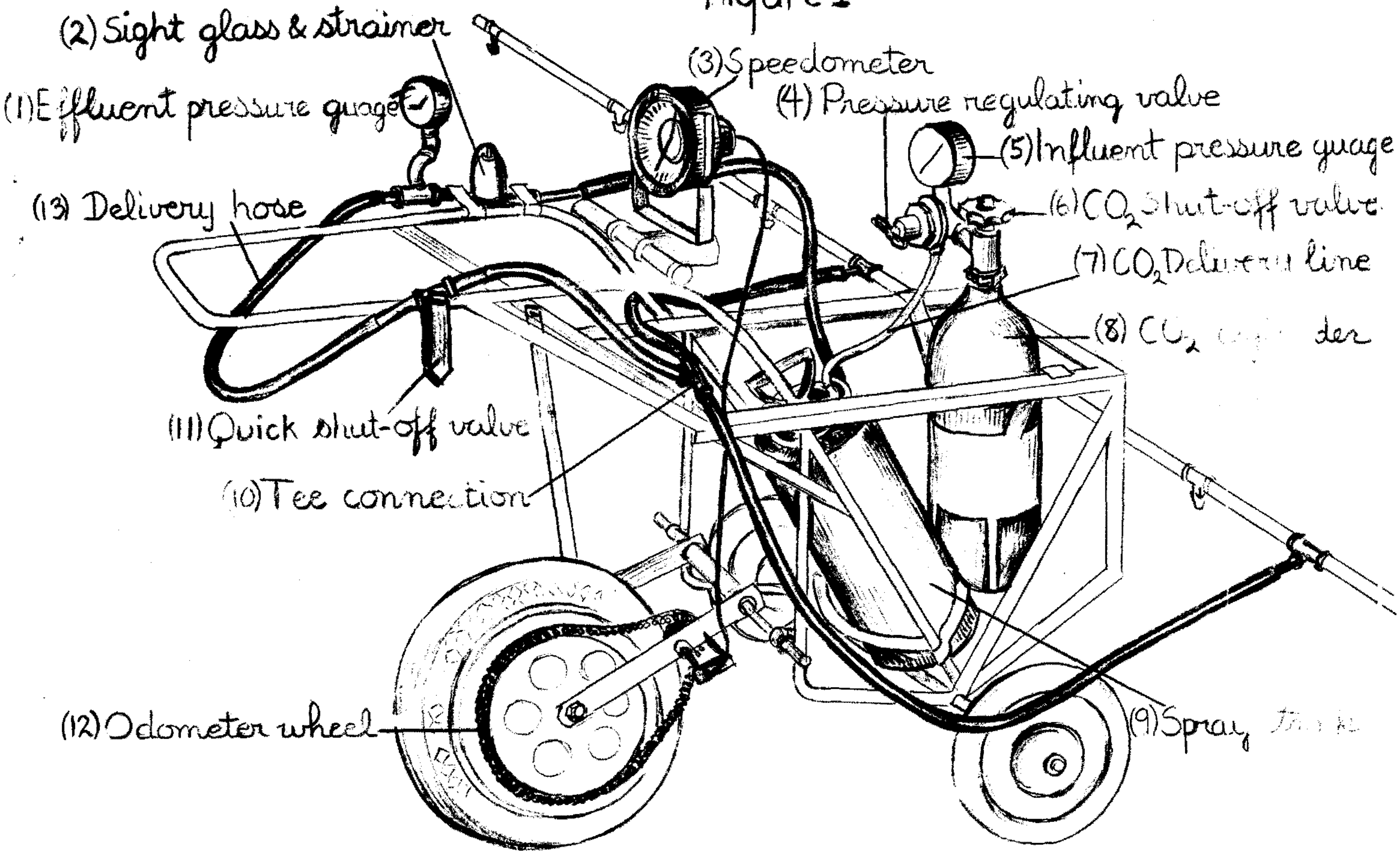
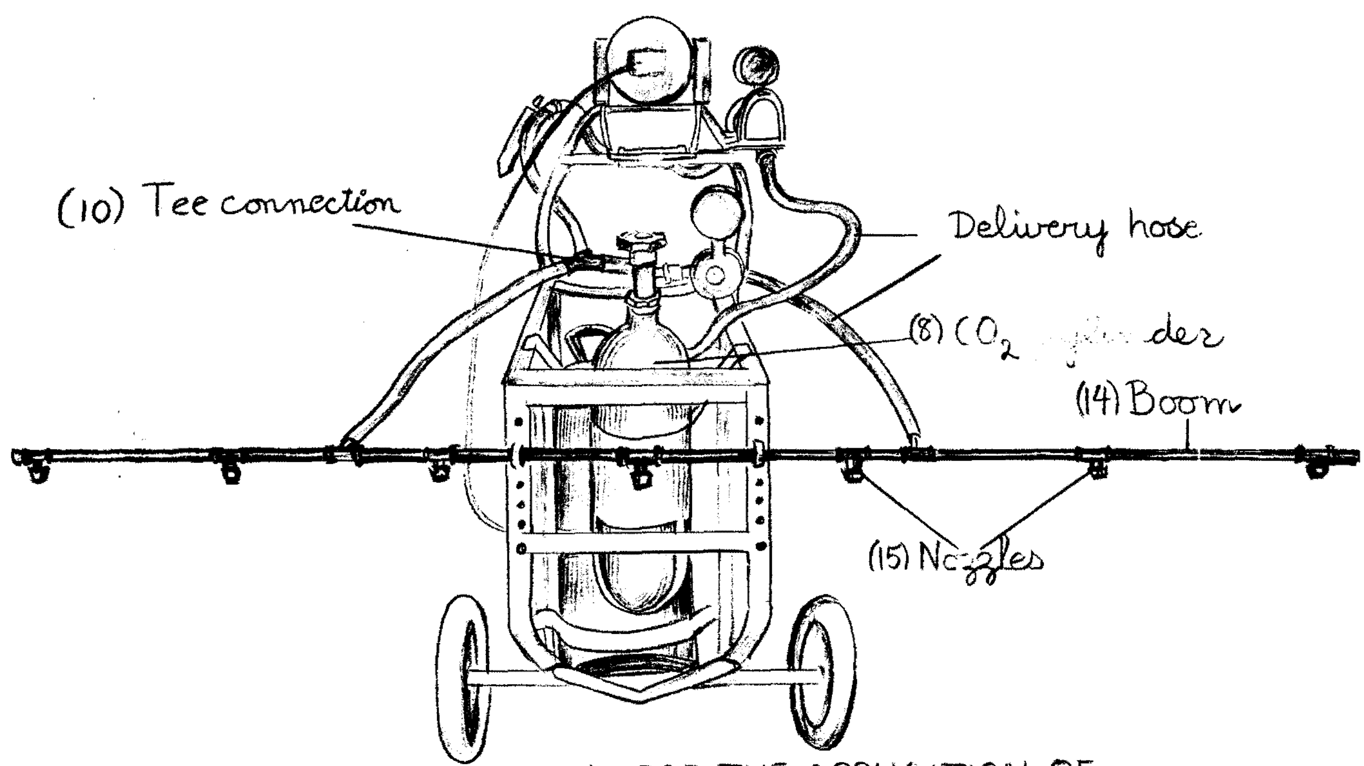


Figure 2



SPECIAL EQUIPMENT FOR THE APPLICATION OF HERBICIDES TO EXPERIMENTAL TURF PLOTS

by Gene C. Nutter Cornell University - 1950

5. Influent Pressure Guage (7).

This guage, mentioned in the previous paragraph, indicates the pressure exerted on the solution in the spray tank.

6. Effluent Pressure Guage (1).

This guage indicates the pressure of the spray solution in the delivery lines (i.e. after it has left the tank) and, for all practical purposes the pressure at the nozzles. This is an important feature because discharge capacities are dependent on the pressure delivered at the nozzle. This pressure can be adjusted by manipulating the pressure regulating valve.

7. Odometer Wheel (12) and Speedometer (3).

It is these features that determine and indicate, respectively, the rate at which the machine is moving on the ground. When operating at a constant discharge rate, the amount of material applied is directly proportional to the rate of travel. This unit is so geared that the speedometer indicates ten times the actual ground speed and the odometer reads in hundreths rather than tenths of a mile.

8. Quick Acting Shut-off Valve (11).

This is a quarter-turn valve which quickly shuts off the flow of spray solution from the tank to the boom. Slower acting valves such as gate or globe type require extra manipulation and thus permit an excess discharge of spray solution at the point where the machine has halted. This results in waste of material and may cause serious discoloration or injury to the turf, as well as making difficult the calculation of volumes necessary for successive replicates.

9. Tee Connection (10).

The tee connection is included in the delivery line to divide the spray solution so that an equal quantity is delivered to each half of the boom. This aids in securing a more even distribution of herbicide from the nozzles.

10. Strainers and Screens

Dust and other foreign particles in the spray line can be a source of much trouble to the operator. Small particles will cause excess wear to, and affect the efficiency of, gauges and valves and will often clog up the small openings in the nozzles. To reduce such hazards in this machine the spray solution is screened or strained at three points in the spray line before reaching the nozzle openings. First, the spray solution is strained through finely meshed cheesecloth before going into the spray tank. Second, a strainer (2) is provided in the line and third, each nozzle is supplied with a screen, the fineness of which varies with the nozzle orifice.

11. Boom (14).

Once the aforementioned features have been properly included in the system the performance of the sprayer is dependent upon the boom. In principle, the boom should be of suitable length to accommodate the width of plot used in experimental work or if plots of various width are used provisions must be indluded on the sprayer for an interchange of booms of different lengths. The height and width of the boom, number and spacing of nozzles, and the type of nozzles selected are all important aspects in the construction of the boom and will be further discussed under Section C.

12. Nozzles (15).

For herbicidal work nozzles producing a fan type spray pattern are best. A great variety of nozzle types and sizes are available on the market. Discharge ratings are usually given in terms of gallons per hour or gallons per acre under conditions of specified operating pressure and rate of travel. Information pertinent to the selection and use of nozzles is usually furnished by the manufacturer Terry ((1))* has very effectively summarized the considerations and calculations necessary for the construction of low volume spray booms.

C CONSTRUCTIONAL FEATURES

1. Frame.

The frame of the present sprayer evolved from a golf caddy cart. The important contributions here were the conveniently designed handles (Fig.1), the support for the spray tank, wheels, and the axle. To this basic structure additional framework was added for a boom support. Light channel and strap iron were used for this construction. Holes were drilled at regular intervals on the two upright boom supports (Fig.2) to allow for adjustment in height of boom. Next a carrier for the CO_2 cylinder was built from sheet iron and welded in place in front of the spray tank. The cylinder can be removed for recharging or transporting purposes merely by being lifted from its support.

2. Odometer Unit.

This unit, developed and discussed by Terry ((2)) is composed of a standard automobile speedometer, a rubber tired wheelbarrow wheel and a chain and sprocket drive. The chain and sprocket drive was connected to the wheelbarrow wheel and this unit attached to the rear of the spray rig by sliding a steel pin through two sleeves welded to the frame. This unit can be easily detached from the rig by removing a cotter pin and sliding the steel pin from the sleeves. The speedometer was clamped on top of the handles in a position easily viewed by the operator and connected to the chain and sprocket drive by a standard speedometer cable and mounting. The unit was originally

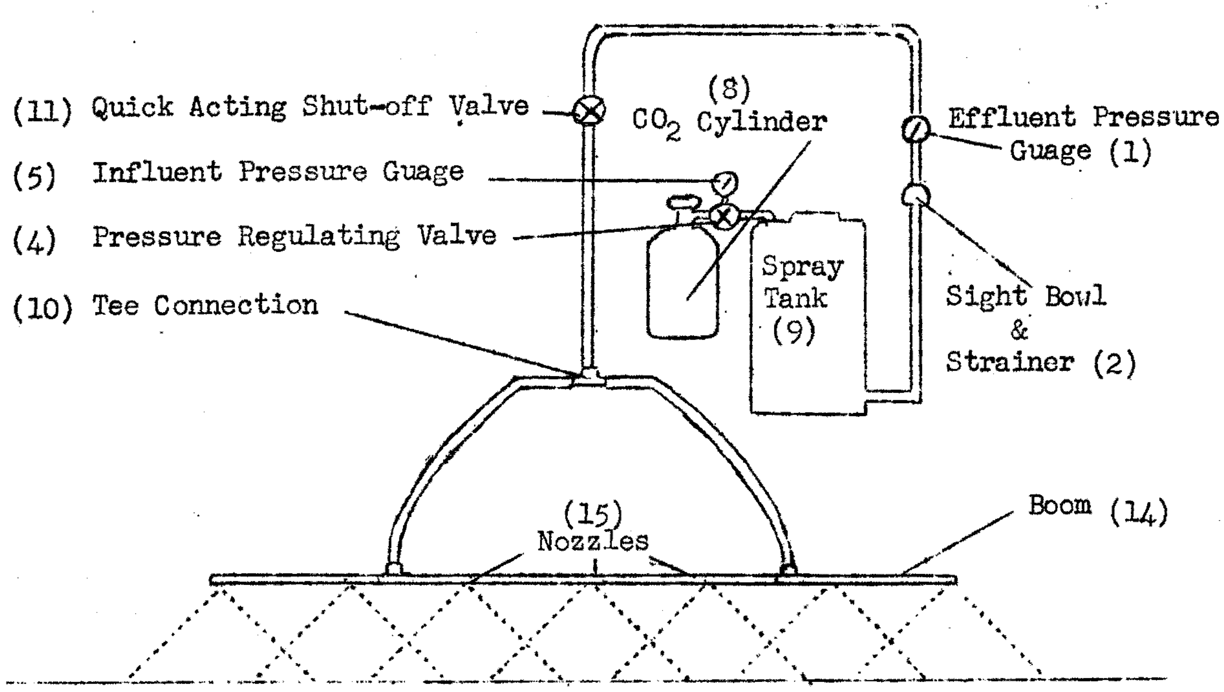
* Double parenthesis (( )) - refere to literature cited to distinguish from diagram references.

calibrated by clocking with a stop watch, the time required to cover a marked distance at each of several speeds. As previously mentioned, the speedometer registers ten times the actual ground speed (i.e. 25 m.p.h. on the meter means 2.5 m.p.h. on the ground.)

3. Spray Line.

The diagram of the spray line and its related features is indicated in Figure 3.

FIGURE 3



FLOW DIAGRAM OF SPRAY LINE AND RELATED PARTS

The CO_2 is supplied to the spray tank through the CO_2 delivery line (#7 Fig.1) with a detachable air valve connection. From the tank the spray solution enters a neoprene rubber hose having an inside diameter of $\frac{1}{2}$ inch. (Fig.2) It first passes into the sight bowl and strainer. (The sight bowl - a standard carburetor sight bowl and mounting - serves the function of indicating when the material in the spray tank is becoming exhausted). Then the solution moves through the effluent pressure guage (1), the shut-off valve (11), is divided at the tee-connection (10) and moves to the boom (14). The spray tank is easily detached from the line to facilitate cleaning and the connection between the line and the boom is easily severed for transporting.

4. The Boom.

The boom was constructed of $\frac{1}{2}$ inch galvanized piping with a coupling in the middle. For a boom height of 20 inches, seven 70° angle nozzles were required spaced 17.5 inches apart. For better distribution a 30% overlap was calculated. Nozzles were selected for the experimental work which would give discharge rates of 10, 50, 100, and 200 gallons per acre (g.p.a.) at pressures of 25 - 40 p.s.i. The distribution pattern of each nozzle was tested in a calibration device ((2)) before the nozzle was used on the spray rig. It was found that in many cases poor distribution patterns were caused by small particles of brass which had not been cleaned from the nozzle after machining. After these particles were removed with a stiff brush, the distribution pattern was usually much improved.

D GENERAL

1. Calibration

Even though careful design and accurate construction have been emphasized it is necessary to calibrate the output of the sprayer under field conditions each time a new or different set of nozzles is used, and at frequent intervals when extensive field work is being conducted.

2. Transportation

A great convenience with this sprayer is the ease with which it can be broken down for transportation. All main accessories can be stripped from the frame including the CO_2 cylinder, the spray tank, the boom, the complete odometer unit and the wheels. This permits the unit to be loaded into a standard automobile trunk for short trips to and from experimental plots.

3. Precautions

Experience has shown that certain precautions cannot be over emphasized when using this sprayer:

a) The spray tank, lines and nozzles should be thoroughly washed after each usage and should be flushed out when changing material during an experiment. In addition to avoiding the intermixing of materials during the experiment this precaution will reduce the corrosive action to metalic surfaces caused by many chemicals used in weed control. Compliance with this measure will increase the life and efficiency of the sprayer.

b) Dogged persistence should be practiced in straining the spray solution entering the tank and in frequent checking of other strainers and screens in the system.

c) All valves and guages should be protected from moisture and other conditions which may affect their operating percision.

d) Proper tools should be used in assembling or disassembling the unit. A common fault is the use of pliers or a pipe wrench on angular headed taps or connections.

e) Moving parts should be suitably lubricated.

The extra time required to perform these cautionary measures will represent much time saved in the final analysis.

E RESUME'

A sprayer was built at Cornell University in 1949 for the application of herbicides to experimental turf plots. It provides for even distribution, accurate allocation and precise application of spray materials by the incorporation of the following features:

1. Controlled, uniform pressure using CO_2, a pressure regulating valve and suitable guages.

2. Controlled rate of travel calibrated and registered by a specially geared odometer.

3. Uniform width and length of coverage afforded by a carefully designed and constructed boom.

The unit is maneuverable, light of weight and can be easily disassembled for transportation.

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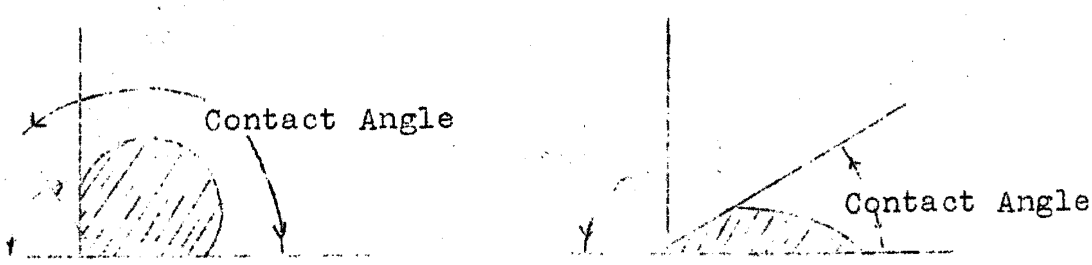
Increasing the Effectiveness of Herbicides by the Addition of Wetting Agents[1]

E. Roland Laning, Jr. and Richard J. Aldrich[2]

A wetting agent can be defined as any substance which when added to surface coatings, such as water or oils, increases the spreading and penetrating action of the solution due to the lowering of the surface tension. A wetting agent also has the property of orienting itself between two interfaces in such a way that it becomes a coupling agent, bringing the interfaces into more intimate contact. These phenomena of decreased surface tension, and action as a coupling agent are considered to be primarily due to the reduction of the contact angle that the droplets of solution make with the material with which they come in contact. Contact angles greater than 90° indicate a surface difficult to wet while any decrease in this angle shows a proportional increase in the ease of surface wetting. This is easily shown in diagram form:



In 1948 wetting agents were used in conjunction with herbicides when Engel[3] and Wolf[4] tested various materials for crabgrass control in turf areas. It was found that the addition of a wetting agent to potassium cyanate increased the effectiveness of the potassium cyanate.

During the summer and early fall of 1949 Walter[5] increased the scope of the tests on turf infested with crabgrass. He

[1]Acknowledgment is made for the support of this project to the General Dyestuff Corporation, New York, N. Y.

[2]Teaching Assistant, Farm Crops Dept., Rutgers University, New Brunswick, N. J. and Agent, USDA, BPIS&AE, Division of Weed Investigations, respectively.

[3]Ralph E. Engel, Research and Extension Associate, Farm Crops Dept., Rutgers University.

[4]Dale E. Wolf, former Agent, USDA, Division of Cereal Crops & Diseases and Associate Research Specialist in Farm Crops, N. J. Agricultural Experiment Station.

[5]Earl E. Walter, former Research Fellow, Farm Crops Dept., Rutgers University.

found that potassium cyanate applied at 16 pounds per acre plus 0.025% by volume of wetting agent (especially Igepon AP Extra Conc.) gave very good crabgrass control. Higher rates of application of potassium cyanate plus wetting agents resulted in undesirable turf injury and concentrations of wetting agent greater than .025% did not show an appreciable increase in crabgrass control.

This early work suggested that wetting agents might increase the effectiveness of herbicides other than potassium cyanate. Consequently in 1950 various tests were run with different types of weed killers, each in combination with wetting agents.

METHODS

1. Post-emergence treatment of corn was made on replicated and randomized plots with 2 rates of 2,4-D amine applied in 10 gallons aqueous solution per acre. Wetting agents were added at 0.1% concentration active ingredient by volume. The incidence of onion top, lodging, and brace root abnormalities in the corn plant were recorded, averaged, and interpreted in percentages of total plant counts per plot.

2. Replicated and randomized turf plots, heavily infested with crabgrass, were treated with 16 pounds of potassium cyanate per acre in 360 gallons of aqueous solution per acre. Seven different wetting agents were added at varying concentrations by volume. Results were recorded as crabgrass control by percentages, and turf injury on the following basis:

0 = no injury
1 = slight injury
2 = moderate injury
3 = severe injury
4 = kill

3. Two groups of replicated and randomized plots of mature Irish potatoes, heavily infested with crabgrass, nutgrass, and Canada thistle as well as other narrow leaf and broad leaf weeds, were treated with 5 and 10 lbs. of sodium arsenite per acre. The sodium arsenite was applied in 100 gallons aqueous solution per acre, both with and without a wetting agent at a concentration of 0.25% active ingredient by volume. The weather was clear and sunny for 9 days following a chemical application in the first test. However, it rained approximately 5 hours after chemical application in the second test. The data collected were the estimated percent of potato vine kill and percent weed kill.

RESULTS

Table I shows the effect on corn of the addition of various wetting agents to 2,4-D amine. In most cases the addition of the wetting agent increased the effect of the herbicide to the extent that 1/4 lb. of 2,4-D plus a wetting agent caused as much or more abnormality as 1/2 lb. of 2,4-D with no wetting agent.

Table I. The effect on corn of the addition of various wetting agents to 2,4-D applied when corn was approximately 30 inches in height.

Lbs. per acre of 2,4-D	Wetting Agent	Total plants counted	% onion top	% abnormal brace roots	% stalks bent at base
1/4	None	106	11.7	35.3	9.8
1/2	None	89	34.0	34.0	12.8
1/4	Nekal N.S.	111	35.3	72.5	25.5
1/2	Nekal N.S.	92	42.5	57.4	19.1
1/4	Igepon AP Extra Conc.	80	24.0	35.9	20.5
1/2	Igepon AP Extra Conc.	109	52.4	65.1	34.9
1/4	Corikal B	98	17.8	11.1	11.1
1/2	Corikal B	98	71.1	86.8	44.7
1/4	Nekal A	93	35.0	35.0	32.5
1/2	Nekal A	96	42.5	45.0	50.0
1/4	Sorapon SB	103	57.4	61.7	44.7
1/2	Sorapon SB	103	68.3	73.2	41.5
None	Nekal N.S.	88	0	0	0
None	Igepon AP Extra Conc.	97	0	0	0
None	Corikal B	82	0	0	0
None	Nekal A	96	0	0	0
None	Sorapon SB	89	0	0	0
None	None	94	0	0	0

2,4-D amine was applied in 10 gallons of aqueous solution per acre. The wetting agents were added at a concentration of 0.1% active ingredient by volume.

Table II presents 2 years data on crabgrass control and turf injury. 1949 was a very dry summer, whereas 1950 was quite wet. In all treatments, however, the addition of the wetting agents enhanced the effectiveness of potassium cyanate for the control of crabgrass. It will also be noted that in most instances the higher concentrations of wetting agent produced more turf injury.

Table II. Two years results of spraying turf with potassium cyanate*
Average of 3 replications.

Wetting Agent	% Conc. W. A.	Date of Application		% Crabgrass control		Turf Injury	
		1949	1950	1949	1950	1949	1950
Nekal NS	.025	8/17		77		0	
	.025	8/25	9/7	87	79	0	0
	.1	8/25		88		1.0	
	.1	9/12	9/7	81	84	1.0	1.66
	.5	8/25	9/7	97	88	.33	1.0
Igepon AP Extra Conc.	.025	8/17		95		2.0	
	.025	8/25	9/7	90	87	0	0
	.1	8/25		92		0	
	.1	9/12	9/7	83	91	1.66	1.66
	.5	8/25	9/7	98	90	.66	2.5
Igepal #300	.025	8/17		85		1.0	
	.025	8/25	9/7	88	80	.33	.5
	.1	8/25		88		.33	
	.1	9/12	9/7	81	82	1.66	1.5
	.5	8/25	9/7	95	85	.33	1.5
Corikal B	.025	8/17		91		1.0	
	.025	8/25	9/7	53	76	0	1.33
	.1	8/25		87		.33	
	.1	9/12	9/7	88	88	1.0	2.0
	.5	8/25	9/7	95	83	.33	2.0
Sorapon SB	.025		9/7		84		0
	.1		9/7		90		1.0
	.5		9/7		90		2.0
[illegible]							
[illegible]							
KOCN alone							

*KOCN applied at the rate of 16 lbs./acre in 360 gal. of water per acre with wetting agent added as percent by volume of total solution.

Table III indicates less effective kill of potato vine and weeds where rain came shortly after application of the arsenite. In either case the percent of kill, however, is considerably greater where the wetting agent was added.

One farmer sprayed 40 acres of potatoes with 2 applications of sodium arsenite at 10 lbs./acre, plus 3 gallons of diesel oil per acre in an aqueous solution at 100 gallons per acre. Fair weather followed for 9 days. He later sprayed a 60 acre field with one application of 5 lbs. of sodium arsenite per

Table III. Effect on potato vines and weeds (broad leaf and grasses) of sodium arsenite and a wetting agent.

Material	Lbs. per acre	% kill Vines	% kill Weeds
A. Treatment preceding rain by nine days			
Sodium arsenite	5	100	70
Sodium arsenite with wetting agent	5	100	98
Sodium arsenite	10	100	80
Sodium arsenite with wetting agent	10	100	99
B. Treatment preceding rain by approximately 5 hours			
Sodium arsenite	5	91.6	41.6
Sodium arsenite with wetting agent	5	100	75.0
Sodium arsenite	10	100	63.3
Sodium arsenite with wetting agent	10	100	81.6

Sodium arsenite was applied in 100 gallongs of aqueous solution per acre. The wetting agent used was Nekal NS at a concentration of 0.25% active ingredient by volume. Evaluation made 10 days after treatment.

acre, plus 0.25% active ingredient Nekal NS (a wetting agent) by volume, in a 100 gallon aqueous solution per acre. Rain fell the evening of the day he sprayed and again the following day. By his testimony, the second application -- that containing the wetting agent -- despite the rain, gave better results within two weeks than did the first application.

Other tests, not replicated, were made in which 0.1% wetting agent by volume was added to chemicals for the following treatments:

(a) 2,4-D on wild onion
(b) T.C.A. on rice cut-grass (Leersia oryzoides)
(c) T.C.A. on Bermuda grass.

Results were in general agreement with those from the more detailed tests.

CONCLUSIONS

The effectiveness of the herbicide was increased in all tests in which wetting agents were added.

Two years results on the use of potassium cyanate for crabgrass control indicate that 0.025% wetting agent by volume provides the maximum increase in effectiveness of the potassium cyanate. The most effective wetting agent studied over the two years was Igepon AP Extra High Conc.

Further work is planned to study the most efficient concentrations of wetting agents to be used with 2,4-D, sodium arsenite, and T.C.A.

The increased effect of the sodium arsenite at low rates of application is particularly promising in view of the fact that much less arsenite is applied to the soil, thus lessening the chance of soil sterilization, and any harmful effect on the potato tubers.

WEED CONTROL IN TURF WITHOUT CHEMICALS

By
Fred V. Grau
Director, U. S. Golf Association Green Section
Beltsville, Maryland

Of all crops grown in the United States specialized turf responds best to proper management thus making it more nearly possible to produce good turf with minimum trouble from weeds and with minimum use of herbicides.

Many weed problems arise as the result of damage to the turf by insects. In this respect chemicals are essential to control the insects and thus to minimize damage, thereby reducing weed invasion. The zoysiagrasses, however, seem to be extremely resistant to insect attacks and, to date, we have recorded no insect damage in our extensive trials at Beltsville. Neither have we had any insect damage reported from our many cooperators.

Weeds in turf may be the result of weak turf caused by diseases. Where disease-susceptible weak and inferior grasses are used, we can expect weeds to be the inevitable result of disease attacks. On small highly-specialized areas of turf some diseases can be controlled with chemicals. For other diseases, however, chemicals are of no avail. Where improved disease-resistant turf grasses are used, weed invasion is greatly reduced because diseases do not weaken the turf.

Compacted soils, and the resultant lack of air in the soil, support turf but poorly and weeds are the inevitable result. Knotweed, goosegrass, crabgrass so often are present because the physical condition of the soil discourages the turf grasses but permits the weeds to flourish. Cultivating the soil under the turf with suitable aerating or aerifying equipment is far more sensible than applying chemicals to treat the symptoms. It always is better to seek the cause of any ill and correct it than to ignore the cause and treat the effects.

Adequate fertilization frequently will mean the difference between weedy turf and "weed-free" turf. Where fertilization and soil cultivation go hand in hand results generally are superior.

Overwatering of turf brings about a number of weed problems which are completely absent when watering practices are satisfactory. Expanded research and education on this phase of management is urgently needed.

We are just beginning to learn to use flexible combs in conjunction with our power mowing equipment. Where this type of equipment has been used properly and consistently, weeds have ceased to be a problem. Crabgrass, in particular, has succumbed to this treatment. Golf course fairways in Denver, in Philadelphia, in Chicago and elsewhere have been nearly crabgrass free with the use of the flexible comb. At Hershey, Pennsylvania, the "vertical mower" has whipped crabgrass without the help of chemicals. This implement is homemade and consists of sharp coulters or straight discs which cut the runners of the crabgrass and thus prevent spread and seed production.

It is our policy to continue to call attention to all methods of weed control and to stress those which are most economical and which are basic to the well-being of plants. We particularly wish to stress the great value of the improved turf grasses which, by virtue of their resistance to diseases, insects and drought, are able to resist weed invasion. The simple process of cultivating turf areas is extremely important in strengthening grass plants against weed invasion.

We recognize that, when the fundamental principles of turf management are neglected, and when weeds enter the picture, chemicals are helpful in restoring the desired balance. The effectiveness of these chemicals is very much greater, and at lower cost, when the cultural and mechanical principles first are invoked. We may not be able to get along without weed control chemicals in turf but at least we can learn to walk without the crutch once in awhile.

Crabgrass Inhibition with O-isopropyl N-(3-chlorophenyl) carbamate.

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Camp Detrick, Frederick, Maryland

O-isopropyl N-(3-chlorophenyl) carbamate possesses the property of preventing germination of crabgrass seed or inhibiting growth of established seedlings at low concentrations, in this respect being substantially more active than O-isopropyl N-phenyl carbamate which, in tests on cereals has hitherto been regarded as the most active representative of the series. The stability and persistence of the 3-chloro derivative in soil is also appreciably greater than that of O-isopropyl N-phenyl carbamate. On the basis of these findings and of pot experiments with peas, soybeans, cotton and strawberry plants, this compound may well find important agronomic uses in controlling the development of crabgrass and perhaps other grassy weeds in non-responsive broadleaf crops.

Chemical Control of Quack Grass

S.M. Raleigh
Pennsylvania State College

An area of a hay field which had been in sod for five years consisting of nearly 100% quack grass, Agropyron repens, was plowed, cultipacked and lightly harrowed on September 12, 1950.

The following treatments were applied in water using 150 gallons per acre on September 21 and 22: 25, 50, 75, 100, 125 pounds of sodium salt and the calcium salt of trichloroacetic, also, 25 and 50 pounds of sodium TCA, each with 1/2 and 1 pound of sodium chlorate. There were two replications on the plowed land and two replications on the original quack grass not plowed.

The calcium salt was somewhat more effective than the sodium salt. It started to kill the quack grass sooner and with the 25 and 50 pound applications there was a better kill. The sodium salt was much harder on the Author's face and hands.

The percent kill of quack grass on the plowed area was as follows: 25#- 80%; 50#- 95%; 75#- 95%; 100#-and above- 100%. The 125 pounds on the sod reduced the stand about 10%. With the low rate there was no reduction. The sodium chlorate increased the efficiency of the 25 and 50 pound TCA rate.

In this area there was considerable smooth leaf Canada thistle, circium arvense, which was not injured by any treatment, even the 125 pounds of TCA per acre.

Corn plots badly infested with quack grass were sprayed with 100 pounds actual TCA per acre on November 8. There was very little reduction in stand of quack grass on these plots. The area was again planted to corn in the spring. The growth of the corn and quack grass was normal.

It has been observed by J.K. Thornton, Farm Superintendent at Pennsylvania State College, in both 1949 and 1950 that corn fields badly infested with quack grass early in the season had very little quack grass remaining at harvest where 1/2 pound of 2,4-D was applied twice while cultivating. Fields not sprayed while cultivating had much quack grass.

FURTHER RESULTS WITH PRE-EMERGENCE WEED CONTROL IN FIELD BEANS

By: A. J. Tafuro[1] and John VanGeluwe[2]

Acreage of dry beans in New York State ranges between 100,000 and 170,000 acres annually, and one of the expensive cost items for this crop is weed control.

In the summer of 1949 the authors made preliminary field tests for pre-emergence weed control on field beans with 2,4-D, Dinitro's, various aromatic oils and an oil-pentachlorophenol mixture. The work was presented to this conference in 1950. To continue the study of weed control for field beans, a large replicated test was conducted by the authors at the University of Delaware. The most effective herbicides were selected from this test and later repeated in two different experiments in western New York State.

Test materials were applied with a low pressure, low gallonage sprayer mounted on a jeep. Applications were made shortly after planting as well as just prior to bean come up. All materials were applied at a volume rate of 15 gallons per acre and also 30 gallons per acre in the Delaware test, but were varied according to materials in the New York State tests.

In the spring of 1950 at the University of Delaware Sub-Station in Georgetown, Delaware, applications of various herbicides were made to two (2) replicates of thirteen (13) plots; 36 feet long and 16 feet wide. Included in each replicate were two (2) unsprayed checks. Six (6) dinitro herbicides and one (1) aromatic oil were applied at 30 gallons of spray per acre and the remaining plots consisted of various oils reinforced with small amounts of dinitros sprayed at the volume of 15 gallons per acre. The beans were planted on April 22, 1950 and herbicides applied six (6) days later. Rain and cool temperatures hindered the normal quick come up of the crop. At the time of application the beans were germinated and the sprouts examined varied from 1/8 inch to one inch in length, or about 48 hours before bean plants came up.

1,2 G.L.F.Soil Bldg.Serv, a div.of Coop.G.L.F.Exchange,Inc,Ithaca,N.Y.

The authors wish to express their appreciation to the University of Delaware for their cooperation in the work conducted at Georgetown; and to Mr. Clyde Byrant of the Dow Chemical Company for helping with the plots

TABLE I

Material	Rate per Acre	Volume of spray per acre	Weed Counts		
			Rep. 1	Rep. 2	Total
Dow Selective (1)	1½ gals.	30	135	26	161
Check A			388	181	569
Dow General (1)	2 pts + 3 gal/oil	30	159	111	270
Premerge (1) 3 lbs/gal	1/2 gal.	30	72	112	184
Premerge (1) 3 lbs/gal	1 gal.	30	51	98	149
Premerge (1) 3 lbs/gal	2 gals.	30	35	28	63
Agrinol A (2)	30 gals.	30	93	85	178
Aromatic oil 180 (3) + Dow General (1)	15 gals. + 1 pt.	15	362	126	488
SV 544C (2) + Dow General (1)	15 gals. + 1 pt.	15	317	107	424
Check B			328	128	456
Agrinol A (2) + Dow General (1)	15 gals. + 1 pt.	15	253	148	401
HAN 132 (3) + Dow General (1)	15 gals. + 1 pt.	15	226	215	441
SV 544-B (2) + Dow General (1)	10 gals. + ½ pt.	15	149	237	386
SV 544-B (2) + Dow General (1)	5 gals. + 1 pt.	15	155	118	273
Agrinol A (2) + Dow General (1)	15 gals + 1 pt.	15	163	193	356

(1) Product of Dow Chemical Co. (2) Product of Socony Vacuum Oil Co. (3) Product of Esso Standard Oil Co.

Table I is a summary of weed counts taken at random from six (6) one foot squares per plot four and one-half ($4\frac{1}{2}$) weeks after the pre-emergence spray was applied.

All applications gave good initial weed control. No visible injury to the field beans was noted except with Premerge at two (2) gallons per acre which gave slight dwarfing of the beans. Premerge and Dow Selective at all rates used, and Agrinol A gave good residual weed control for four (4) weeks. Residual effects of all other herbicides depleted approximately two (2) weeks after application under the weather conditions prevailing that season on the Delmarva Peninsula.

To further test some of the more promising of these herbicides one test was conducted on the farm of Everett Blazey in Victor, New York and another experiment at the farm of Charles Rooke in Alloway, New York. Plots on the Everett Blazey were 16 feet wide and 150 feet long. The spray application was made on June 20th, about 24 hours before bean plants came through the ground.

Table II is a summary of weed counts taken from ten (10) one foot squares taken at random on different dates after spray was applied.

TABLE II

Material	Rate per Acre	Vol. per Acre	Weed Counts			
			6/28	7/6	7/18	Total
Dow Selective	$1\frac{1}{2}$ gals.	30	6	6	13	25
Premerge 3 lbs/gal	$\frac{1}{2}$ gal.	30	3	2	8	13
Premerge 3 lbs/gal	1 gal.	30	0	3	4	7
Check			27	29	57	113
Sinox PE 3 lbs/gal(1)	$\frac{1}{2}$ gal.	30	6	10	24	40
Sinox PE 3 lbs/gal(1)	1 gal.	30	6	1	10	17
Agrinol A	30 gal.	30	9	25	66	100
Agrinol A + ACP 646-A	15 gal + 1 lb.	15	6	8	8	22
Premerge	$1\frac{1}{2}$ gals.	30	0	2	3	5

(1) Product of Standard Agricultural Chemicals Inc.

Weed counts were made on the 8th, 16th and 28th day after the spray was applied. Little differences can be noted in weed control due to the light infestation, but the water soluble dinitros again gave the best control, as in the previous experiment in Delaware.

Premerge made by Dow Chemical Co. and Sinox PE made by Standard Agricultural Chemicals gave good weed control for four (4) weeks. Agrinol A gave good initial control of weeds but depleted in two (2) weeks. Agrinol A plus 1-lb. of ACP646-A gave excellent weed control, but gave serious injury to the bean plant.

A second field test was conducted in Alloway, New York. Plots were 16 feet wide and 300 feet long with four (4) unsprayed rows between the plots used as uncultivated checks. The spray application was made June 21st, two (2) days after planting or just as bean seeds began to sprout. Weed infestation was heavier on this field trial but results were similar. Weed counts were made on the same dates as in the first experiment in New York state (8th, 16th and 28th day after treatment).

Table III summarizes weed counts at three (3) different time intervals from fifteen (15) one foot squares, taken at random.

TABLE III

Material	Rate per Acre	Vol. per Acre	Weed Counts				
			6/28	7/6	7/18	Total	Avg.
Dow Selective	1½ gals	30	30	33	63	126	126.0
Premerge 3 lbs/gal	½ gal.	30	34	34	60	128	121.5
Premerge 3 lbs/gal	1 gal.	30	21	23	56	100	
Check A			165	132	217	514	478.5
Check B			115	104	224	443	
Sinox PE 3 lbs/gal	½ gal.	30	36	47	70	143	107.0
Sinox PE 3 lbs/gal	1 gal.	30	10	13	48	71	
Agrinol A	30 gal.	30	74	97	187	358	358.0
Agrinol A + ACP 646-A	30 gal + 2 lbs.	30	11	13	38	62	62.0

LSD-1% 2 x 2 - 149.75
2 x 1 - 183.41
1 x 1 - 211.78

Comparing Sinox PE and Premerge at both dosages, both gave highly significant control of weeds over the checks. When compared alone, both Dow Selective and ACP 646-A plus Agrinol A were highly significant in weed control over Agrinol A used alone. However, the ACP 646-A gave serious injury to the bean plants. It is obvious from the figures that Agrinol A lost its efficiency in approximately two weeks.

SUMMARY

1) The water soluble dinitro materials consistently gave the best residual weed control in all experiments and eliminated two cultivations.

2) Agrinol A and other aromatic oils alone or oils reinforced with dinitros gave good initial weed control but residual effect depleted in about 10 to 14 days.

3) ACP 646-A gave good residual control of weeds but gave serious injury to the bean plants.

4) Premerge and Sinox PE at both one-half gallon and one gallon per acre rates gave similar results in both New York State tests.

5) Dinitros used in these experiments seem safe to apply from planting time up to just prior to come up. The only exception to this was the slight injury with Premerge at two gallons per acre only on light, sandy soils on the Delmarva Peninsula.

CONCLUSIONS

1) Premerge and Sinox PE gave good residual weed control for at least four (4) weeks at the rate of one (1) gallon per acre (3 lbs. toxicant).

2) Premerge and Sinox PE were equally effective on the two extremely different soils types: the light sandy soils on the Delmarva Peninsula and the heavy loam type of soil in the New York State tests.

3) The length of time of residual weed control decreased with Premerge and Sinox PE when the concentration was reduced to 1/2 gallon per acre.

4) The Premerge and Sinox PE gave no injury and did not decrease yields at the rates necessary for weed control for at least four (4) weeks.

Two Years Results on the Effect of 2,4-D on Certain Legumes

L. G. Butler and Richard J. Aldrich[1]

The affect of 2,4-D butyl ester on the stands of legumes common to hayfields and pastures of the Northeast and the possibility of using that chemical for weed control in these crops were investigated at the New Jersey Station during 1949 and 1950.

1949 Tests

Pure stands of Northwestern alfalfa, Cumberland red clover, super alsike clover, and ladino clover were seeded the first week in September, 1948. A severe infestation of perennial thistle (Cirsuim arvense L. Scop.) rendered the ladino plot useless for experimental work during the 1949 season. On April 27 and May 7, 1949, each of the first three named species was treated with 1/8, 1/4, and 1.0 lb. of 2,4-D per acre in 5 gallons of water per acre. The legumes were in the vegetative phase of growth on both dates. On April 27 the average heights, in inches, of the legumes were: alfalfa 12, red clover 10, and alsike 9. On May 7 the average heights were: alfalfa 16, red clover 14, and alsike 13 inches.

Spring oats, Northwestern alfalfa, Cumberland red clover and ladino clover were seeded together (a mixture) the first week in April, 1949. These plots were treated on May 14, May 24, June 2, and June 18 with 1/16, 1/8, and 1/2 lb. of 2,4-D per acre applied in 5 gallons of water per acre. The average heights of the vegetation on the dates of treatment are given in Table 1.

Table 1. Average heights, in inches, of the vegetation in a spring oats-legume spring seeding at 4 dates of treatment, 1949.

Date	Oats	Alfalfa	Red Clover	Ladino Clover
	in.	in.	in.	in.
May 14	6	2	1½	1
May 24	9	4	3	2
June 2	12	6	5	3
June 18	22 (head)	9	6	5

[1]Agricultural Aideand Agent, USDA, Bureau of Plant Industry, Soils and Agricultural Engineering, Division of Weed Investigations, respectively.

The month of June was without rainfall, a highly abnormal situation for New Jersey.

The estimated percentage composition of the plant population in all the various plots on September 15 is given in Tables 2 and 3. The May 7 treatment did not produce the severe reduction in alfalfa stand as did the April 27 treatment. The reasons for this difference between dates are, as yet, unknown. The alsike clover made such a poor recovery following cutting that it was difficult to accurately evaluate the actual effect of the 2,4-D.

Table 2. Percentage composition on September 15, 1949 of pure stands of alfalfa, red clover and alsike clover following 3 rates and 2 dates of treatment with 2,4-D butyl ester.

lbs. of 2,4-D per acre	April 27 Percent Alfalfa	April 27 Percent Weeds	May 7 Percent Alfalfa	May 7 Percent Weeds
0.0	96	4	95	5
1/8	63	37	93	7
1/4	16	84	78	22
1.0	9	91	50	50
	Red Clover	Weeds	Red Clover	Weeds
0.0	94	6	94	6
1/8	74	26	82	18
1/4	57	43	39	61
1.0	40	60	18	82
	Alsike	Weeds	Alsike	Weeds
0.0	44	56	84	16
1/8	41	59	30	70
1/4	17	83	11	89
1.0	10	90	7	93

In the spring oats-legume spring seeding, alfalfa was the predominant legume. The 1/16 lb. per acre rate was most injurious when applied on the first and second dates. It appears that these legumes are least tolerant of 2,4-D while in the seedling stage. In addition, during this seedling stage, the oat foliage did not supply much protection. As the legumes increased in height and the oat leaves provided more protection, the injury sustained was decreased. The 1/8 lb. per acre treatment eliminated practically all the alfalfa and 1/3 of the red clover except on the last date when the vegetation was not actively growing. The 1/2 lb. per acre rate eliminated all the alfalfa at the first three dates and practically all red clover at all four dates. The amount of ladino tended to increased with

Table 3. Percentage composition on September 15, 1949 of a spring oats-legume spring seeding following 3 rates and 4 dates of treatment with the 2,4-D butyl ester.

Date	lbs. of 2,4-D per acre	Percent Alfalfa	Percent Red Clover	Percent Ladino Clover	Percent Weeds
May 14	0.0	68	16	10	6
	1/16	3	2	15	80
	1/8	6	6	17	71
	1/2	0	0	4	96
Average		19	6	12	63
May 24	0.0	72	13	10	6
	1/16	5	6	19	70
	1/8	0	3	21	76
	1/2	0	0	3	97
Average		19	6	13	62
June 2	0.0	64	16	12	8
	1/16	13	6	28	52
	1/8	4	2	27	67
	1/2	0	2	16	82
Average		20	7	21	52
June 18	0.0	55	16	22	7
	1/16	42	13	12	33
	1/8	36	6	21	37
	1/2	38	1	17	44
Average		43	9	18	30
	Average of 4 dates of application				
	0.0	65	15	13	7
	1/16	16	7	18	59
	1/8	11.5	4	21.5	63
	1/2	9.5	1	10	79.5

with increases in 2,4-D up to 1/8 pound per acre, due perhaps to its higher tolerance of 2,4-D, decreased competition and, since ladino is slow to germinate and establish, perhaps new plants were produced.

1950 Results

Pure stands of Northwestern alfalfa, Cumberland red clover, super alsike, and ladino were seeded in the first week of September, 1949. A prolonged fall drought combined with severe winter killing necessitated replanting. This was accomplished in the middle of March, 1950. A companion crop of spring oats, planted at the rate of 1/2 bushel per acre was used to insure a stand of legumes.

The oats were clipped at the height of the tallest legume just prior to treatment and the clippings carefully removed. On June 13 and June 24, each of the above named species was treated with 1/8, 1/4, and 1.0 lb. of 2,4-D per acre applied in 5 gallons of water per acre. On June 13, the average heights, in inches, of the vrious legumes were: alfalfa 10, red clover 8, alsike 7, and ladino 4. On June 24, the average heights were: alfalfa 14, red clover 12, alsike 11, and ladino 8 inches. On both dates, all the legumes were in the vegetative phase of growth.

Spring oats, Northwestern alfalfa, Cumberland red clover, and ladino clover were planted as a mixture during the second week in April. These plots were treated with 1/16, 1/8, and 1/2 lb. per acre of 2,4-D in 5 gallons of water per acre on June 13, June 24, July 1 and July 12. The average heights, in inches, of the vegetation on the four dates of treatment are given in Table 4.

Table 4. The average heights, in inches, of the vegetation in a spring oat-legume spring seeding at 4 dates of treatment, 1950.

Date	Oats in.	Alfalfa in.	Red Clover in.	Ladino Clover in.
June 13	7	2	2	1
June 24	10	5	4	2
July 1	15	9	7	3
July 12	28 (head)	12	10	5

The month of June had 2.28 inches of rainfall in contrast to no rainfall for the same period in 1949.

The estimated percentage composition of the plant population in all the plots on September 15 is given in Tables 5 and 6.

In the pure stands of legumes, the decrease in stand seemed quite consistent as the rate of 2,4-D increased. Ladino clover appeared to be more tolerant of the 1/8 and 1/4 lb. per acre rates than the other three species.

In the spring oats-legume spring seeding, red clover was the predominant legume. This may have been a seasonal response, the months of April and May were cooler, cloudier, and drier than last year. The 1/16 lb. per acre rate decreased the amount of alfalfa and appeared to have little effect on the red clover or ladino. The 1/8 lb. per acre rate eliminated all the alfalfa except on the last date. Red clover appeared to be reduced slightly by the 1/8 lb. per acre rate. The 1/2 lb. per acre rate eliminated all alfalfa on all dates and all red clover except on the last date. The percentage of ladino increased as the rate of 2,4-D increased. Possible explanations for the increase in ladino were discussed in connection with 1949 results.

Table 5. Percentage composition on September 15, 1950 of pure stands of alfalfa, red clover, alsike clover and ladino clover following 3 rates and 2 dates of treatment with 2,4-D butyl ester.

Rate	June 13		June 24	
	Percent Alfalfa	Percent Weeds	Percent Alfalfa	Percent Weeds
0.0 lb./A	95	4	96	4
1/8	64	36	59	41
1/4	15	85	18	82
1.0	1	99	4	96
	Red Clover	Weeds	Red Clover	Weeds
0.0 lb./A	95	5	95	5
1/8	83	17	71	29
1/4	8	92	13	87
1.0	0	100	2	98
	Alsike	Weeds	Alsike	Weeds
0.0 lb./A	89	11	93	7
1/8	78	22	82	18
1/4	28	72	31	69
1.0	1	99	2	98
	Ladino	Weeds	Ladino	Weeds
0.0 lb./A	94	6	95	5
1/8	83	17	79	21
1/4	57	43	62	38
1.0	3	97	4	96

Summary

1. No 2,4-D rates effectively controlled weeds without reducing the stands of alfalfa, red clover, alsike, or ladino when seeded alone or in mixture with oats as a companion crop.

2. Ladino was more tolerant of 2,4-D than alfalfa, red clover, or alsike.

3. The percentage of weeds increased with increases in rates of 2,4-D, the predominant increase being in the weedy grasses.

Table 6. Percentage composition on September 15, 1950 of a spring oats-legume spring seeding following 3 rates and 4 dates of treatment with the 2,4-D butyl ester.

	lbs. of 2,4-D per acre	Percent Alfalfa	Percent Red Clover	Percent Ladino Clover	Percent Weeds
June 13	0.0	6	84	2	8
	1/16	2	85	4	9
	1/8	0	81	11	8
	1/2	0	0	22	78
Average		2	62	10	26
June 24	0.0	5	85	4	6
	1/16	2	83	6	9
	1/8	0	74	17	9
	1/2	0	0	37	63
Average		2	60	16	22
July 1	0.0	7	85	3	5
	1/16	5	82	4	9
	1/8	0	75	18	7
	1/2	0	0	55	45
Average		3	60.5	20	16.5
July 12	0.0	8	83	4	5
	1/16	4	81	6	9
	1/8	1	76	16	7
	1/2	0	5	64	31
Average		3	61	23	13
Average of 4 dates of application					
	0.0	6.5	84	3	6.5
	1/16	3	83	5	9
	1/8	0	76.5	15.5	8
	1/2	0	1.3	44.5	54.3

PRELIMINARY REPORT ON THE USE OF CALCIUM CYANAMID FOR WEED CONTROL IN LEGUME SEEDINGS[1]

-- W. H. Mitchell and C. E. Phillips[2]

On many Delaware farms the partial or sometimes complete loss of stand in grass-legume seedings due to weed competition has become a common occurrence. An experiment in the use of calcium cyanamid for weed control in pasture and hay seedings has been carried on during the past year.

This test was made on two separate grass-legume seedings (1) alfalfa and brome grass (2) Ladino clover and orchard grass. The plot layout consisted of a randomized block design to which granular cyanamid was applied at three rates -- 400, 600, and 800 pounds per acre and at two different times -- 14 and 7 days before seeding. All treatments were made in triplicate on 1/100 of an acre plots. The cyanamid was broadcast by hand on a well-prepared seedbed and then mixed to a depth of about 3 inches with a disc harrow. The percentage of grass, legumes, and weeds was determined by harvesting two separate square foot areas chosen at random in each plot.

The results of the experiment on alfalfa and brome grass are not shown here due to the absence of any serious weed competition. However, results of this phase of the work showed no significant decrease in stand due to any of the treatments.

Summarized below are the results of the experiment on Ladino clover and orchard grass. The values given are expressed by percentages on a weight basis.

Treatment	Percent Grass	Percent Legumes	Percent Weeds
A.. 400 lbs. cyanamid	44	25	30
B.. 400 lbs. cyanamid	52	26	22
A.. 600 lbs. cyanamid	48	31	21
B.. 600 lbs. cyanamid	67	27	7
A.. 800 lbs. cyanamid	71	19	10
B.. 800 lbs. cyanamid	68	21	11
Check	49	35	16

A.. 14 days before seeding
B.. 7 days before seeding

1. Published as Miscellaneous Paper No. 100 with the approval of the Director of the Delaware Agricultural Experiment Station.

2. Assistant Research Professor and Head, respectively, Department of Agronomy, Delaware Agricultural Experiment Station.

The weed population was made up largely of common chickweed (Stellaria media), lamb's quarters (Chenopodium album), henbit (Lamium amplexicaule) and galinsoga (Galinsoga parviflora). The 400 pound application of cyanamid appears to have had no adverse effect on weeds when applied either 7 or 14 days prior to seeding. The same is true of the 600 pound application made 14 days before seeding. However, on the plots where 600 pounds were applied 7 days before seeding there is a decrease in the percentage of weeds as compared to the check plot. This is also true at the 800 pound level for each time of application of the cyanamid.

The 600 and 800 pound treatment of cyanamid show a decided increase in the growth of grass. However, since this is a new seeding the growth of grass has not been excessive in any of these plots.

Although these results are not at all conclusive they do show promise and this work will be continued more extensively in 1951.

Acknowledgement

Acknowledgement is gratefully made to the American Cyanamid Company for the material used in this experiment.

Chemical Control of Wild Garlic (*Allium Vineale*)

S.M. Raleigh
Pennsylvania State College

Wild garlic in two of the same pastures as reported at the Conference last year were treated April 16, 1950, with 1/2, 1 and 2 pounds of an ester of 2,4-D and 1, 2, and 3 pounds of an amine of 2,4-D. In one pasture, the plants were 14 to 16 inches tall with clumps 3 to 4 inches in diameter, while in the other pasture the height was between 3 and 4 inches.

There was nearly complete killing of all plants which were above the soil level with 1 and 2 pounds of the ester and the 2 and 3 pounds of the amine. There were many escape plants with the 1/2 pound ester and the 1 pound of amine. These escape plants produced hard bulblets. They were in the center of the clumps, especially the tall area and in areas where the plants were protected by grass and weeds.

The plots where the soft bulb plants were killed by spraying in 1948 and the hard bulblets which germinated in the fall of 1948 were retreated with one pound of an ester in 1949. This treatment easily killed the plants which germinated from the hard bulblets. In the spring of 1950 the area treated twice had some plants which germinated from small bulblets. Therefore, to control garlic in pasture, it is necessary to treat once each spring for three years.

The wild garlic in the pastures of this area germinated about October 1st this year and are now about 7 inches tall (November 11, 1950) while last year in the same area the plants were about 12 inches tall with well formed bulblets. These bulblets did not become hard but germinated in the spring of 1950.

COMPARISON OF DIFFERENT HERBICIDES, VOLUME PER ACRE AND ARTIFICIAL WATERING AFTER SPRAY APPLICATION ON LEGUME SEEDLINGS IN MUSTARD INFESTED OATS

By: A.J.Tafuro[1], C.V.Flagg[2] and John VanGeluwe[3]

A high proportion of grains in the northeast are seeded to legumes, mostly mixed legumes. Weeds not only effect normal growth of grains but also compete with legume seedlings. For the past two years the authors made preliminary tests with triethanolamine salt of 2,4-D for weed control in seeded grains ahd have also made close observations on grower sprayed trials.

When triethanolamine salt of 2,4-D was applied to grains that had an infestation of weeds, mostly mustard, severe enough to warrant spraying, little or no injury to the legume seedlings was observed.where the volume of spray was reduced to 5 - 6 gallons per acre.

An experiment using four hormone type materials at two different concentrations and two different dinitros at the same concentrations was conducted on the farm of Carl Rinell at Frewsburg, New York. Materials used were triethanolamine salt of 2,4-D at 1/8 and 1/4 pound acid equivalent per acre; ACP-638* at 1/8 and 1/4 pound acid equivalent per acre; ACP-954** at 1/4 and 1/2 pound acid equivalent per acre; Dow's Selective at two quarts per acre and Sinox W at two quarts per acre. The plots were 40 feet long and 16 feet wide with 25 foot buffer strips between each plot. Application was made with a low pressure, low volume sprayer mounted on a jeep. The individual replicates A and B; and C and D were 25 feet apart to avoid spray drift and each set of replicates was 75 feet apart. Plots in replicate A and C were sprayed at 12 gallons of volume spray per acre, while B and D were sprayed at the rate of 6 gallons of total spray per acre.

1,2,3 G.L.F.Soil Building Service, a div. of
Coop. G.L.F.Exchange, Inc. Ithaca, N.Y.

* ACP-638 (American Chemical Paint Co) is a water emulsifiable 2,4-D acid containing 3-lbs. per gallon

** ACP-954 (American Chemical Paint Co) is 2-methyl-4-chlorophenoxyacetic acid containing 2-lbs. per gallon.

At the time of spray application the mustard weeds were in full bloom and starting to form seed pods. The oats were approximately a few days prior to the boot stage. Two hours after application was made replicates C and D were sprayed with water at the rate of 600 gallons per acre at 500 pounds pressure per square inch.

All materials used in this test gave excellent control of mustard at this time of application, and at all rates used. ACP-964 at equal rate of application (1/4 pound of acid equivalent) gave slightly better mustard control as compared to 2,4-D and ACP-638. The results are given in Table I.

TABLE I

Decrease in number of mustard plants three weeks after treatment

Repl.	Rate	1/4 lb. acid equivalent		
		2,4-D	638	964
A	12 gal/acre	405	508	603
B	6 gal/acre	838	748	917
C	12 gal/acre + water	407	70	300
D	6 gal/acre + water	311	323	472
	Totals	1961	1649	2292

Total counts of mustard plants and legume seedlings (both alfalfa and ladino clover) were taken in identical marked areas before and after spraying. These were taken in 18 inch squares in each of four quadrants in each plot. A second count was taken three weeks after the spray was applied, in the same marked squares.

Table II gives the alfalfa counts as calculated statistically, corrected by the use of regression from the original number of plants in each sample and shows the effect of the volume rate of the various materials applied.

TABLE II

Rate						
6 gal/acre L.D. no water after spraying	1	90.3	140.6	295.4	520.2.	Total
12 gal/acre L.D. no water after spraying	d	50.3	154.8	224.8	-117.2**	D
6 gal/acre H.D. no water after spraying	h	92.4	125.5	-70.0	-12.0	H
12 gal/acre H.D. no water after spraying	dh	62.4	99.3	-47.2	+23.8	DH
6 gal/acre L.D. + water after spraying	w	71.1	-40.0	+14.2	-70.6*	W
12 gal/acre L.D. + water after spraying	wd	54.4	-30.0	-26.2	+22.8	WD
6 gal/acre H.D. + water after spraying	wh	64.9	-16.7	+10.0	-40.4	WH
12 gal/acre H.D. + water after spraying	wdh	34.4	-30.5	+13.8	+ 3.8	WDH

Significant level 4th column 5% 72 ± 33.5
1% 100

** Highly signficantly more plants with 6 gal/acre volume (26.56 plants per plot) over 12 gal/acre (16.76 plants per plot) volume spray per acre.

* Artificial spraying of water after the spray was applied approached 5% level as giving less alfalfa plants in July than without water

Table III gives the ladino clover counts as calculated statistically, corrected by regression from the original number of plants in each sample and shows the effect of the volume rate of the various materials applied.

TABLE III

6 gal/acre I.D.no water after spraying	1	85.5	153.9	296.3	523.7	Total
12 gal/acre L.D.no water after spraying	d	68.4	142.4	227.4	-96.9*	D
6 gal/acre H.D. no water after spraying	h	76.5	102.0	-27.7	+11.9	H
12 gal/acre H.D. no water after spraying	dh	65.9	125.4	-69.2	-28.5	DH
6 gal/acre L.D. + water after spraying	w	62.8	-17.1	-11.5	-68.9	W
12 gal/acre L.D. + water after spraying	wd	39.2	-10.6	+23.4	-41.5	WD
6 gal/acre H.D.+ water after spraying	wh	85.5	-23.6	- 6.5	+34.9	WH
12 gal/acre H.D. + water after spraying	wdh	39.9	-45.6	-22.0	-15.5	WDH

Significant level 4 th column 6% 87
1% 121

*Probably signficantly more ladino clover plants per plot in July using 6 gal/acre (25.96 plants per plot) as compared to 12 gal (17.28 plants per plot) volume spray per acre.

Tables II and III show that when using hormone type materials for weed control in grains seeded to legumes, there was highly significantly (1%) more alfalfa plants in plots sprayed at 6 gal/acre volume as compared to the volume rate of 12 gallons of spray per acre; and probably significantly (5%) more ladino clover plants in plots sprayed at the lower volume per acre as compared to the higher volume spray. Ladino clover, being less susceptible to 2,4-D, again showed the same general trend with other hormone type herbicides.

Since alfalfa is a more susceptible legume as compared to ladino clover, the counts on the reduction of alfalfa plants in both the low and high volume spray replicates are combined for each of the different hormones in the case of the alfalfa counts with and without forced artificial watering. The results are given in Table IV.

TABLE IV	
1/8 pound 2,4-D	29.12
1/2 pound 954	28.38
1/4 pound 2,4-D	20.42
1/4 pound 954	18.98
1/8 pound 638	18.42
1/4 pound 638	14.72
LSD 1% 12.13	

ACP-954 at 1/2 pound acid equivalent per acre and triethanolamine salt of 2,4-D at 1/8 pound acid equivalent per acre are highly significant (1%) over 1/4 pound of ACP-638 as to the number of alfalfa plants per plot.

Although the counts were not quite significant with ladino clover, which is a more resistant clover to the hormone type of weed killer, they follow the same general trend, showing ACP-954 safer even at the dosages used which are above that needed for mustard control. Here again, as in the above alfalfa counts (Table IV) 1/2 pound of acid equivalent of ACP-954 was about equal in its effect on ladino clover stands as compared to 1/8 pound of acid equivalent of the amine salt of 2,4-D.

Although two different dinitro materials were included in this test with good weed control and little injury to the legume seedlings, both gave injury to the grain crop (oats). When using dinitros on seeded grains in the past years, results have been erratic as to the amount of injury incurred on both grain and legume seedlings depending on climatic conditions.

CONCLUSIONS

1) All materials used gave excellent control of mustard at all rates used. At equal rate of application (1/4 pound acid equivalent per acre) ACP-954 gave a slightly better mustard control as compared to ACP-638 and triethanolamine salt of 2,4-D.

2) When the total spray volume per acre was increased from 6 to 12 gallons there was a significant (1%) decrease in alfalfa plants per plot and a probable significant (5%) decrease in ladino clover plants

3) The addition of water to simulate an artificial rain, two hours after spray application, approached 5% level in the reduction of alfalfa plants as compared to plots not receiving the forced watering.

4) ACP-954 at 1/2 pound acid equivalent per acre gave considerable decrease in number of mustard plants over 1/8 pound of triethanolamine salt of 2,4-D. Although this high rate is above that needed for good mustard control, the effect of ladino clover plants as well as alfalfa, which is more susceptible to 2,4-D, was similar to triethanolamine salt of 2,4-D at the lowest rate of 1/8 pound acid equivalent per acre.

5) ACP-954 appears safe to use on legume seedlings (both alfalfa and ladino clover) at rates even above that needed for good mustard control when using 6 gallons volume spray per acre and the mustard infestation is severe enough to warrant spraying for weed control.

THREE YEARS RESULTS WITH 2,4-D FOR PRE-EMERGENCE WEED CONTROL IN CORN ON COASTAL PLAIN SOILS[1]

-- C. E. Phillips[2]

An experiment in the use of 2,4-D as a pre-emergence spray for the control of weeds in corn was initiated in 1948 at two locations, one at Newark on a Sassafras silt loam and the other near Georgetown on a Norfolk loamy sand. The plots were 14 x 40 feet with four replications in a randomized block arrangement. All treatments were applied at the rate of 10 gallons of liquid per acre. No treatment plots were included in each replication. All control data given in the tables was taken 8 weeks after planting.

The rainfall by weeks from day of planting is given in Table I.

Table I. Inches of Rain by Weeks from Day of Planting.

Week	Newark			Georgetown		
	1948	1949	1950	1948	1949	1950
1	1.21	.30	.25	.14	.95	1.90 (1.85)
2	.94	1.79	.70	4.68 (2.89)	0	1.06
3	.19	.04	.72	3.39 (2.08)	.01	.28
4	3.21 (2.00)	.90	.49	0	.55	1.70
5	1.14	.56	1.97 (1.76)	3.70 (2.59)	.04	1.51
6	.58	.33	1.18	.02	.09	1.57
7	.15	0	.08	.85	.16	.54
8	1.14	1.89	.04	.66	3.07	0

Note: Figures in parenthesis are the inches of rain for the 24 hour periods during which the rainfall exceeded 1.50 inches.

The rainfall at Newark in 1948 and 1950 was near normal and fairly well distributed. In 1949 it was below normal.

At Georgetown the rainfall in 1949 was excessive. In the first five weeks after the corn was planted there were three days with rainfall in excess of 2.00 inches in 24 hours. 1949 was quite dry and corn yields in the area were very low. In 1950 1.85 inches of rain fell in about one and one-half hours on the fourth day after planting. The remainder of the period was near normal.

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2. Head, Department of Agronomy, Delaware Agricultural Experiment Station.

Results

None of the treatments gave any control of weeds at Georgetown in 1948. As shown in Table I the rainfall was excessive and the 2,4-D apparently was leached from the surface layer of soil.

The 1948 data for Newark is presented in Table 2.

Table 2. Results of Pre-emergence Treatments at Newark, 1948.

Form of 2,4-D	Rate Per Acre lbs.	At Planting Weed Control*	At Planting % Damaged Plants	6 Days Before Planting Weed Control	6 Days Before Planting % Damaged Plants
Triethanolamine	.5	2.7	1.2	2.7	2.4
"	1.0	3.0	1.3	3.3	10.7
"	1.5	2.7	3.4	3.7	17.9
Butyl Ester	.4	2.7	2.4	2.3	14.9
"	.8	3.0	1.2	2.7	23.8
"	1.2	2.0	2.4	3.0	34.6

* 0 = No control; 5 = No weeds.

Complete control was not secured on any of the plots. There were very few broad-leaf weeds present but crabgrass and foxtail came in. The most satisfactory control was with 1.5 pounds of 2,4-D as triethanolamine applied 6 days after planting. However there was but little difference between the 1.5 and 1.0 pound rates. The triethanolamine seemed to give slightly better results than the butyl ester.

The application made six days after planting caused considerable damage particularly at the higher rates. At the time this application was made the plants had been through the ground about 24 hours and were about one inch high. This probably accounts for the much greater damage caused by the butyl ester.

The 1949 results are shown in Table 3.

Table 3. Results of Pre-emergence Treatments with 2,4-D, 1949.

Form of 2,4-D	Rate Per Acre lbs.	At Planting		4 Days After Planting	
		Newark	Georgetown	Newark	Georgetown
Triethanolamine	.5	1.2[1]	1.0	2.2	1.3
"	1.0	4.8[2]	2.8	3.0	4.5
"	1.5	4.0	4.8	4.0	4.3
Butyl ester	.5	2.2	1.0	1.8	1.0
"	1.0	3.5[2]	1.3	3.5	2.8
"	1.5	4.0	1.0	4.0	4.0

1. 0 = No control; 5 = No weeds.
2. These plots received an additional 1.0 pound application 4 days after planting.

At Newark the 1.5 pound rate in general gave quite satisfactory control, the .5 pound rate very little control. There was only a slight difference between the applications made at planting and those made 4 days after planting. One treatment gave practically perfect control. By mistake this set of plots received 1.0 pound of 2,4-D at planting and another 1.0 pound application 4 days later. There were very few damaged plants in the entire experiment.

At Georgetown the only treatment applied at planting which gave good control was 1.5 pounds of triethanolamine. For the 4 days after planting treatments satisfactory control was obtained with both the 1.0 and the 1.5 pound applications of triethanolamine. The 1.5 pound application 4 days after planting was the only butyl ester treatment to give good control.

Several of the new formulations of 2,4-D were introduced into the experiment in 1950. The data is presented in Table 4.

Table 4. Results of Pre-emergence Treatments with 2,4-D, 1950.

Form of 2,4-D	Rate Per Acre lbs.[1]	At Planting Newark	At Planting Georgetown	6 Days after Planting Newark	6 Days after Planting Georgetown
Sodium 2-(2,4-dichlorophenoxy) ethyl sulfate	2.0	3.0[2]	.5	3.0	3.0
Butoxy ethanol ester	1.0	1.0	.5	2.0	3.3
Butoxy ethanol ester	1.5	1.3	.5	2.8	3.8
Pentasyl ester	1.0	2.8	.8	4.5	3.5
"	1.5	4.5	.8	5.0	3.5
Triethanolamine	1.0	3.0	.5	4.8	3.5
"	1.5	4.3	.8	5.0	2.8
Acetanalide (in No. 2 Fuel Oil)	1.0	4.0	1.3	4.8	4.0
Acetanalide (in No. 2 Fuel Oil)	1.5	4.5	2.0	5.0	3.8

1. Except for the first treatment all rates are given in terms of pounds of 2,4-D equivalent per acre.
2. 0 = No control; 5 = No weeds.

At Newark good control was obtained with at planting applications of 1.5 pounds of pentasyl ester, triethanolamine and acetanalide (in fuel oil). The acetanalide at the 1.0 pound rate gave almost as good control. Practically no weed control was secured with the butoxy ethanol ester even at the 1.5 pound rate. For the six days after planting applications excellent control was obtained with both 1.0 and 1.5 pound rates of pentasyl ester, triethanolamine and acetanalide (in fuel oil).

At Georgetown satisfactory control was not secured with any treatment applied at planting. On the fourth day after planting 1.85 inches of rain fell in approximately one and one-half hours. The only material that seemed to have any resistance to the leaching action of this heavy rain was the acetanalide in the No. 2 fuel oil. The degree of control secured with applications made 6 days after planting did not vary greatly between materials. Best results, however, were secured with the acetanalide (in fuel oil) and the 1.5 pound rate of butoxy ethanol ester.

There was some evidence that some of the materials used in 1950 caused excessive damage. At Newark the plots treated with sodium 2-(2,4-dichlorophenoxy) ethyl sulfate at both times of application showed some reduction in stand. This was also true of the at-planting treatment of 1.5 pounds of pentasyl ester and the 6 days after planting treatment of acetanalide in fuel oil at both rates. The plots, however, were machine planted and the evidence is not conclusive. At Georgetown two out of the four plots treated with butoxy ethanol ester at the rate of 1.5 pounds of 2,4-D per acre showed a stunted growth, approximately 75 percent of normal. This same treatment also gave an average of 11.5 percent damaged plants. The only other treatment causing any appreciable amount of damaged plants was the sodium 2-(2,4-dichlorophenoxy) ethyl sulfate at 2 pounds per acre. Plots receiving this treatment averaged 20 percent damaged plants.

Summary and Conclusions

1. 2,4-D gave reasonably satisfactory control of weeds in corn when applied as a pre-emergence spray on a Sassafras silt loam.

2. On a Norfolk loamy sand the control of weeds with 2,4-D as a pre-emergence spray depends on the amount and intensity of rainfall after planting.

3. One and one-half pounds of 2,4-D as amine applied 4 to 6 days after planting gave the most satisfactory control.

4. 2,4-D at rates of 1.0 pound or more per acre caused excessive damage to plants that had just emerged from the soil.

Acknowledgement

Acknowledgement is gratefully made to the American Chemical Paint Company and the Carbide and Carbon Chemicals Corporation for materials supplied for the 1950 experiment.

SOIL FACTORS AFFECTING CORN GROWTH USING HERBICIDES AND CULTIVATION FOR THE CONTROL OF WEEDS 1/

C. L. W. Swanson and H. G. M. Jacobson 2/

With the advent of chemical weed killers, a new tool has been made available for studying the effect of soil physical properties on crop growth. Questions arising for which this new tool may be used for solving them are "What are the beneficial effects, if any, accruing from cultivation for the control of weeds?" "Is cultivation necessary for maximum production?"

The literature is replete with experiments giving conclusions that the main reason for cultivation is to control weeds (4,5,7,11,12,16,17,18). Many of the textbooks on soils and crops state that cultivation is mainly for the control of weeds (2,9,10,15,22). In controlling weeds by cultivation, it is pointed out that competition for soil moisture and plant nutrients is reduced. Weeds transpire large amounts of moisture and this loss is eliminated when weeds are destroyed by cultivation.

Much of the work on the value of cultivation was done earlier, and after the general conclusion had been reached that the chief value of tillage was as a weed-control measure, little has been done in recent years. However, if these earlier experiments are examined closely, one learns that plots were kept weed free by scraping or quick-chopping of the weeds. Mosier and Gustafson (12) describe the method of control used on a weed-free plot as "scraping with a sharp hoe so as to produce practically no mulch". This same method was used by Cates and Cox (5). They state "particular care was to be paid not to stir the soil any more than absolutely necessary." They believed that the principal value of cultivation lies in the killing of weeds and not in the aeration of the soil or the conservation of moisture. They based their conclusions on 125 experiments conducted in 28 states from 1905 to 1911 in which regular cultivation was compared with scraping with a hoe to destroy weeds. The scraped plots produced on an average 99.1 percent as much corn as did the cultivated plots.

Soil Factors and Plant Growth

There are several soil factors which affect plant growth. Chief among them is the nature of the soil itself which includes its physical as well as chemical properties. A great deal of attention has been given to the chemical or fertility status of the soil, but less to its physical nature. In recent years, more attention is being devoted to this phase of soils research.

One of the major reasons for doing research using herbicides for weed control is to produce larger crop yields at less cost. Most of the experiments have been concerned with the effects herbicides have on weeds and the crop in question, which is work that must be done, but little attention has

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1/ Contribution from the Department of Soils, Connecticut Agricultural Experiment Station, New Haven, Conn.
2/ Chief Soil Scientist and Soil Scientist, respectively.

been given to soil factors as they may affect production when herbicides are used. Several workers have investigated the effects of herbicides on the microbiological population of the soil (14).

With herbicides like 2,4-D and others available, weeds can now be controlled, at least initially, without disturbing the soil surface. Effect of non-disturbance of the soil surface could now be compared with disturbance by cultivation. This allowed study of the effect of the physical properties of soil, especially that of the soil surface, on crop growth. Two years results using this approach comparing cultivation versus no cultivation for weed control are now available.

Experimental Details

In order to test the hypothesis that cultivation may be beneficial in ways other than in controlling weeds, corn plots were set up on Cheshire loam soil at the Station's Mt. Carmel Farm in 1948. The following treatments were laid out: (1) Pre-emergence control of weeds in corn with 2,4-D and post-emergence spray 45 days later (non-cultivated); (2) Control of weeds in corn by flaming + cultivation (flamed three times and cultivated once same time as last cultivation of cultivated plots); and (3) Control of weeds in corn by ordinary clean cultivation methods. All of the plots received equivalent fertilization. Corn was used, for this plant is an excellent indicator of plant nutrient deficiencies, especially nitrogen, phosphorus and potassium. Details of the experiment have been reported elsewhere (20,21).

Weather Conditions, Herbicides and Soil Compaction

In growing crops in the field, unusual weather conditions sometimes have more effect on the crop grown than does the cultural treatments. The years 1948 and 1949 afforded an excellent opportunity for studying the effects of cultivation versus no cultivation on crop growth. During those years, unusually heavy rains fell, packing the ground. Later in the season, it became unusually hot and dry, baking the soil and forming a hard crust on the surface.

The effect of this soil crust was measurable not only in decreased corn yield but also in soil property changes. In 1948, differences in growth did not show up until the corn was about a foot high, In the 2,4-D plots the corn was smaller, lighter green and less vigorous than that on the cultivated plot (21). The differences showing up were due to the hard surface crust. Evidently this crust did not allow free circulation of air into the soil, setting up reducing conditions, and resulted in a decrease in the production of nitrates by soil organisms. The plot was practically weed free so no competition was offered for moisture and plant nutrients. There were no observable 2,4-D injuries. Height measurements of the corn 50 days after planting gives an index of its later growth. The 2,4-D-treated corn averaged about 3 1/2 inches shorter than the cultivated corn.

Comparison of the corn yields with the physical nature of the soil shows the importance of good soil structure on crop growth. For the surface 2 inches, the arithmetical difference in amount of large pores between the cultivated as against the 2,4-D plots was 3.4 percent more large pores (20.2 and

16.8 percent, respectively) in the cultivated ones (20). Percentage-wise this is a 20 percent difference. The yields were 61.5 and 15.2 bushels, respectively, or 46.3 bushels more for the cultivated corn.

Although weeds were well controlled for the first month in the 2,4-D plots. some broadleaf weeds started coming in along with grass weeds (mainly foxtail and crabgrass). A second application of 2,4-D at the end of the last cultivation killed most of the broadleaf weeds but the grasses were not affected. As mentioned above, corn growth was more vigorous and the plants larger in size on the cultivated plots. Evidently the combined effect of corn and weeds on use of the moisture supply in the 2,4-D plots was less than in the cultivated plots. This strongly suggests that weeds were not the limiting factor in plant growth in the 2,4-D plots, but that the poor physical condition of the soil was the limiting factor.

Further evidence that the physical nature of the soil affects crop growth is afforded by the flamed plots. The effect of breaking up of the surface crust by the one cultivation is reflected in the yield difference of only 8.8 bushels in comparison with the cultivated plots. The amount of large pores for the 2 plots is about the same, 21.1 and 20.9 percent, respectively. Flaming kept weeds down initially but did not kill all of them. It was estimated that after the flamed corn was cultivated that about 10-15 percent of the ground was covered with grass weeds (mostly crabgrass). It was noticed that after the flamed corn was cultivated, it became darker green in color, indicating greater nitrification activity in the soil. This fact, together with the yield differences in comparison with the cultivated plots, indicates the importance of loosening hardened surface soil. Also, the surface crust on the flamed plots appears to be responsible for the retarded growth (7 inches shorter than cultivated corn 50 days after planting).

On the basis of data obtained during 1948 the plot set-up was revised and moved in 1949 to the Humphrey plot area of the Station Farm having the same soil type. Flaming of weeds was omitted and scraping with a hoe for weed control similar to that described by Cates and Cox (5) and Mosier and Gustafson (12) was added. In addition, pre-emergence control of weeds with 2,4-D + one cultivation coinciding with the last cultivation for the cultivated plots was included in the experiment. All of the plots were randomized.

Studies conducted in 1949 confirmed the observations made in 1948. In many respects, weather conditions were similar; a wet spring followed by a hot dry summer producing soil crusting.

The following per acre corn yields were obtained: cultivated - 94.6; 2,4-D + one cultivation - 84.7; scraped - 80.3; 2,4-D only - 68.3. The yield differences were not as large as those obtained in 1948 but they followed the same pattern - a difference of 26.3 bushels between the cultivated and 2,4-D-only treated corn. No injuries to the corn by 2,4-D were observed.

Macroporosity differences in the surface 2 inches of soil (cultivated - 19.75; 2,4-D - 17.76 percent) were not as large as in 1948. This is in line with the corn yield differences, there being 46.3 bushels in 1948 and 26.3 bushels larger yield in 1949 for the cultivated plots. Heights of stalk (91.9 and 78.4 inches, respectively) and diameter of stalk at 3-foot height (0.82 and 0.60 inches, respectively) taken on August 26 compare favorably with the physical status of the soils in these plots. In obtaining soil cores for porosity determinations, a record was kept of the amount of force required to force the core sampler into the soil (19). To penetrate the surface 2 inches, an average of 10.25 strokes of a 12-pound hammer falling 2 feet were required in comparison with 5.75 strokes for the cultivated plots. Thus 78 percent more force was required to break through the soil in the 2,4-D plots than in the cultivated ones.

It is difficult to make comparisons using the scraped plots as having undisturbed soil. It is practically impossible to use a hoe for cutting off the weeds at the ground level and not disturb the soil surface. For this reason the authors do not consider these plots as having an undisturbed soil surface throughout the growing season as contrasted with the 2,4-D plots. The effect of disturbing the soil surface is seen in a comparison of the yields for the scraped and the 2,4-D + one cultivation (80.3 and 84.7 bushels, respectively). Further evidence of disturbance is shown in the 18.44 percent surface macroporosity as compared with the cultivated and 2,4-D plots mentioned above. Increased height (79.6 inches) and diameter (0.61 inches) of stalk as compared with the 2,4-D plots show the effect of disturbing the surface of the soil.

In 1949, nitrate nitrogen tissue tests (8) were made on August 30 of the corn stalk 4-6 inches from the ground surface. Arbitrary values of 0 for "no nitrate" and 12 for "high test nitrates" were set up. On this basis the reading for the cultivated, 2,4-D + cultivation, scraping, and 2,4-D-only plots were 11.0, 6.25, 6.37, and 4.37, respectively. These readings are in line with the other data reported above, reflecting the effect of the poor physical nature of soils on plant growth.

Nitrate nitrogen studies were made of the plow depth layer of soil (0-8 inches) at intervals throughout the growing season. It is interesting that immediately after cultivating the 2,4-D + cultivation plots that the nitrate nitrogen content went up from 76.5 to 81.1 pounds per acre (July 7 and July 27, respectively). This strongly suggests that breaking of the surface crust permitted free movement of air in the soil and made conditions more favorable for nitrification. In contrast, the cultivated plots decreased from 75.6 to 48.5 pounds per acre for these same dates. (The trend for the cultivated plots was from a high to a low amount of nitrates as the season progressed.) This suggests that the cultivated corn plants were growing vigorously, utilizing the nitrates about as quickly as they became available. On the other hand, the plants in the 2,4-D plots were not able to take up the nitrogen as quickly and it was not until later that the plants grew vigorously enough to utilize the available nitrates. For example, on the next sampling (August 8) the nitrate nitrogen content had decreased to 58.3 pounds per acre while that of the cultivated plots was 37.1 pounds.

Discussion

It appears from a review of the early literature that one serious error was made in the research techniques used for studying the effect of weeds on crop production. The early researchers failed to take into account the effect of surface soil compaction on plant growth. The surface inch or two of the soil was disturbed in scraping off the weeds. In the experience of the authors, it is practically impossible to cut off weeds with a sharp hoe without cutting into the soil. The weeds have to be cut off flush with the soil surface to kill them, and this operation breaks open the soil surface. In fact, what actually happens is that the soil is skimmed which tends to leave a fine soil mulch on the surface. Under these conditions, air can easily enter the soil and reducing conditions would not exist.

With the advent of herbicides, weeds can be controlled without disturbing the soil. This offers a new tool for studying the effect of the physical nature of soils on crop production. In particular, the effect of cultivation on crop response can now be more accurately measured.

The data presented for two seasons are not conclusive proof that cultivation is always desirable. It is believed that the usefulness of cultivation will vary with weather conditions and with soil types. In some seasons it may not be necessary to cultivate. Such a season would be one with rain of low intensity occurring rather frequently supplying adequate moisture for maximum crop production. Thus the soil surface would not be compacted and air could move easily in or out of the soil. In seasons having rains of high intensity which result in packing of the soil, and especially if this is followed by a hot dry period, cultivation would be essential for maximum crop production. The crust formed on the soil surface will need to be broken if reducing soil conditions are to be avoided. On the lighter soils of a sandy texture it is conceivable that the coarse nature of the soil will prevent soil crusting and no benefits from cultivation will accrue. In the heavier soils, hard rains will pack the soil, washing the silt and clay fractions into the soil pores, stopping the movement of air, especially at the soil-air interface.

The pore space of the soil is filled with varying proportions of air and water reciprocally related to each other. When the pores are filled with water, the air is completely displaced. When the pores in the surface soil-air interface are clogged, the supply of oxygen to higher plants and soil micro-organisms is greatly diminished. Soil crusting is an example of clogged pores. Silt and clay fractions have been washed into the pores by rain water forming a baked surface on exposure to a hot drying sun. Unless the crust is broken by cultivation, anaerobic conditions will prevail for air can enter the soil only slowly. Little oxygen will be brought into the soil by rain water for the solubility of oxygen in water is small (0.04 cc/ml). The rate of movement of oxygen through soil pores filled with water is too slow to meet the demands of a normal soil flora. Under such anaerobic conditions, the soil will be reduced if a sufficient amount of readily oxidizable organic matter is present and if the soil temperature is favorable for microbiological activity. Under such conditions, some soil constituents become toxic to plants, changing from the oxidized to the reduced state (3) as follows:

Element	In Oxidized Soil	In Reduced Soil
Carbon	CO_2	CH_4, aldehydes, etc.
Nitrogen	NO_3	NO_2, NH_4^+, N_2
Sulphur	$SO_4^=$	$SO_3^=$, $S^=$
Iron	Fe^{3+}	Fe^{2+}
Manganese	Mn^{4+}	Mn^{3+}, Mn^{2+}

In the case of nitrogen in a reduced soil, ample supplies of nitrates will not be available for maximum growth and nitrogen deficiencies in the plant will show up. The ammonia form of nitrogen can be utilized by some plants but not as quickly and in as large quantities as the nitrates. Nitrites in appreciable amounts are toxic.

In the plots reported on, weeds were not eliminated altogether in the 2,4-D plots. The plots were weed free for the first month and then grass (foxtail and crabgrass) started coming in. Later post-emergence applications of 2,4-D practically eliminated the plots of the broadleaved variety of weeds. Weed competition, then, was controlled initially and reduced to about 60 to 75 percent control in the latter part of the season. Techniques are now being worked out to get 100 percent weed control throughout the season without cultivation.

Results obtained in 1949 for the 2,4-D + one cultivation plots point out that a combination of herbicides plus cultivation might result in maximum crop production, at lease for seasons of high intensity rains which pack the soil surface. In seasons of low intensity and abundant rainfall, cultivation might be dispensed with on the lighter soils, and a combination of herbicides used for controlling weeds. This might be a pre-emergence herbicide like 2,4-D to control the weeds for the first month, then using a post-emergence spray of 2,4-D to kill the broadleaved weed varieties, and some other herbicide for controlling the grass weeds. At the present time, however, a herbicide for killing grass types of weeds in cultivated crops like corn is not available.

It is quite likely that one explanation for the diversity of results (1,6,13,23) obtained where 2,4-D was applied and not cultivated, in contrast to 2,4-D + cultivation can be attributed to soil factors. For valid comparison of results, the soil type should be included in the description of the experiment and such information as is available regarding its physical characteristics. It would be especially helpful in analyzing the results of an experiment if nitrogen deficiencies, if they occurred, were noted. It is altogether possible that, in many instances, 2,4-D has been blamed for lower yields which correctly should be attributed to soil factors.

Summary

A review of the literature on the early work of the effect of cultivation compared with no cultivation (plots kept weed-free by scraping) on corn revealed that in the scraping plots the soil surface had been disturbed. This disturbance of the soil allowed an interchange of soil-air gases, especially oxygen, at the soil-air interface. It is believed that these earlier experiments were not a fair comparison between cultivated and non-cultivated corn plots. With the advent of herbicides, a new tool is available for checking on the effect of cultivation versus no cultivation.

Corn plots were set up on a Cheshire loam soil in 1948 and 1949 to test the significance of cultivation on corn growth. During those years, unusually heavy rains fell, packing the ground. Later in the season, it became unusually hot and dry, baking the soil and forming a hard crust on the surface.

Comparisons were made in 1948 between clean cultivation, pre-emergence 2,4-D, and flame + one cultivation (coincided with last cultivation of cultivated plots) treatments for weed control; in 1949, these treatments were clean cultivation, scraping, 2,4-D only, 2,4-D + one cultivation. Post-emergence applications of 2,4-D were made about 50 days after the initial application.

Comparison of the corn yields with the physical nature of the soil shows the importance of good soil structure on crop growth. Yields in 1948 for cultivated versus 2,4-D treated plots were 61.5 and 15.2 bushels, respectively; in 1949, they were 94.6 and 68.3. In 1948, the cultivated plots had 20 percent more large soil pores in the surface 2 inches than the 2,4-D treated plots; in 1949, this difference was 11 percent. Penetrometer studies in 1949 revealed that 78 percent more force was required to break through the surface 2 inches of soil in the 2,4-D-treated plots than in the cultivated ones.

The effect of cultivation in breaking the soil crost is brought out by cultivating the flamed plots once corresponding with the last cultivation of the cultivated plots. The flamed corn yielded only 8.8 bushels less than the cultivated corn. In 1949, plots treated with 2,4-D + one cultivation yielded 9.9 bushels less than the cultivated ones. In 1948, the flamed corn became darker green in color after cultivation, indicating greater nitrification activity in the soil. In 1949, nitrate nitrogen studies of the 0-8 inch soil depth showed that immediately after cultivating the 2,4-D + cultivation plots the nitrate nitrogen content went up from 76.5 to 81.1 pounds per acre.

Weeds in the 2,4-D plots were controlled initially for the first month. It was estimated that weed competition was reduced to about 60 to 75 percent control in the latter part of the season.

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Weed Control in Corn

S.M. Raleigh, R.E. Patterson
and J.E. Steckel

This is the fifth year in which calcium cyanamid has been studied as a pre-emergence weed control treatment at Pennsylvania State College.

In six outlying experiments, weed control and fertilizer trials were conducted as three experiments on the same field. Cyanamid was applied at the rate of 80, 120, and 160 pounds of nitrogen over the row (1/3 of the area) which would furnish 27, 40 and 53 pounds of nitrogen. Ammonium nitrate was applied in a deep band at planting time at the rate of 27, 40 and 53 pounds of nitrogen per acre, and at the same rate as a side dressing. 2,4-D was applied at planting time at the rate of 1, 2 and 3 lbs. of 2,4-D amine per acre. All treatments as well as the check received 200 pounds of 5-10-10. There was also a check and a cyanamid treatment that were weed free making 63 plots per test. In a seventh only cyanamid and 2,4-D were tested. We used three replications with 50 foot single row treated plots with borders. The weed experiment was set up to test the value of nitrogen as a fertilizer material.

Because the spring was wet, most of our cooperators fitted the land several times with a harrow making weeds scarce and therefore all plots were clean with regular cultivation.

We got very little increase in yield from nitrogen whether it was applied as a pre-emergence weed control, deep band at planting or as a nitrogen side dressing. On three fields where there were many stones, we got injury from 2,4-D especially at the three pound rate.

At State College, cyanamid was applied in a band 1 foot wide at the rate, over the row, of 80, 120 and 160 p unds of nitrogen and 1, 2 and 3 pounds of 2,4-D per acre. In each treatment, corn was planted 1, 2, and 3 inches deep. There were four replications using four rows fifty feet long.

There was some 2,4-D stunting in the plots planted shallow and treated with three pounds of 2,4-D.

Four Years Results with Calcium Cyanamide for Weed Control in Corn[1]

Charles S. Gould and Richard J. Aldrich[2]

Since 1947 the Agricultural Experiment Station at Rutgers has been experimenting with calcium cyanamid as a pre-emergence treatment on corn. Pre-emergence treatments have been made on sandy and loamy soils and at various times after planting. Data on weed control, yield, and protein content of the grain were secured.

1947 and 1948

Wolf and Ahlgren[3] established in 1947 that the granular form of cyanamid[*] was somewhat better than the pulverized form and that applying cyanamid to the surface was better than mixing it with the soil. All subsequent work at Rutgers was conducted with the granular form.

Briggs and Wolf[4] in 1948 expanded the work to ascertain the optimum rate of cyanamid application for the most practical weed control and yield increases. Results of their work indicated that cyanamid was a more effective weed killer when applied a few days after planting rather than at the time of planting. On sandy soils increases were obtained in yield and protein content of the grain as a result of the cyanamid treatments.

1949

Experiment I

This experiment was conducted on a loamy sand containing 82% sand, 9% silt, and 9% clay. Corn hybrid , N.J. #7 was planted on May 7, 1949. Cyanamid was applied at three dates, viz. at planting time, four days and seven days after planting. Table I shows the results of Experiment I.

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[1]Acknowledgment is made to the American Cyanamid Company for their support of this project.

[2]Research Fellow, Farm Crops Dept., Rutgers University, and Agent, USDA, BPIS&AE, Division of Weed Investigations, respectively.

[3]Wolf, D. E. and G. H. Ahlgren. "Pre-emergence control of weeds in corn with calcium cyanamide". Jour. Amer. Soc. of Agron. 40: 568-570.

[4]Briggs, R. A. and D. E. Wolf. Annual Report to the American Cyanamid Company, 1948.

[*]Refers to the commercial product.

Table I. Effect of granular cyanamid on weed stand, corn yields, and protein content of corn grown in a loamy sand soil, 1949.

Lbs. of cyanamid per acre	Weeds per sq. ft.*	Bu. #2 corn per acre*"	% nitrogen*#	% crude protein*'
		Applied at Planting		
0	19.9	43.4	1.221	7.63
200	19.7	59.1	1.405	8.78
400	10.5	64.3	1.459	9.12
600	15.4	61.7	1.550	9.69
800	7.4	64.0	1.554	9.71
Av. of treated plots	13.2	62.3	1.492	
		4 Days after Planting		
0	34.1	50.2	1.263	7.89
200	16.5	69.4	1.368	8.55
400	7.6	65.3	1.489	9.31
600	7.5	62.9	1.389	8.68
800	3.3	70.9	1.458	9.11
Av. of treated plots	8.7	67.1	1.426	8.91
		7 Days after Planting		
0	29.2	45.9	1.191	7.44
200	12.3	61.8	1.350	8.44
400	3.6	60.8	1.357	8.48
600	1.8	67.8	1.433	8.96
800	3.7	64.3	1.571	9.82
Av. of treated plots	5.4	61.2	1.428	8.93

*Average of 3 replications

"L.S.D. for weeds - 6.4 weeds per sq. ft. @ 5% level

#L.S.D. for yields - 8.7 bushels #2 corn @ 5% level

'L.S.D. for % nitrogen - 0.17% @ 5% level.

When compared with the check all rates gave significant reductions in weed counts and significant increases in yields and protein content of the grain. The 400#, 600#, and 800# treatments were significantly better than the 200# treatment for weed control. There are no statistically significant differences in weed counts between the 400#, 600#, and 800# treatments.

Differences in yields between treatments were not significant.

The 800# treatment increased the protein content significantly over the 200# treatment but not over the 400# and 600# treatments.

Interaction between rate of cyanamid and date of application was not significant.

Experiment II

Experiment II was conducted on a sandy loam soil containing 54% sand, 26% silt, and 20% clay. N. J. #7 hybrid corn was planted May 16, 1949. Cyanamid was applied three and seven days after planting. The results from this experiment are given in Table II.

Table II. Effect of granular cyanamid on weed stands, corn yields, and protein content of corn grown in a sandy loam soil, 1949.

Lbs. of cyanamid per acre	Weeds per sq. ft.*	Bu. #2 corn per acre*	% Nitrogen*	% crude protein
		3 Days after Planting		
0	115.2	84.0	1.467	9.17
200	71.1	81.0	1.540	9.63
400	35.3	93.7	1.654	10.34
600	47.7	94.4	1.617	10.73
800	29.3	93.0	1.692	10.58
Av. of treated plots	45.9	90.5	1.625	10.16
L.S.D. for weeds - 26.0 weeds/sq. ft. @ 5% level				
		7 Days after Planting		
0	115.2	84.0	1.467	9.17
200	44.9	85.0	1.573	9.83
400	35.9	90.3	1.619	10.12
600	15.4	96.8	1.616	10.10
800	16.7	90.4	1.634	10.21
Av. of treated plots	28.2	90.6	1.610	10.06
L.S.D. for nitrogen - .325 @ 5% level				

*Average of 3 replications.

Since the protein content of the grain was very similar for the three and seven day treatments the two dates were lumped together. Differences in protein content were not significant.

All treatments gave significant weed control over the check, but differences between treatments were not significant. Yield differences were not statistically significant.

1950

The data for 1950 are not completely analyzed. However, Table III again shows that the cyanamid treatments gave good weed control on sandy soils. Differences between rates were not significant.

Table III. Effect of granular cyanamid on weed stands on two sandy loam soils, 1950.

Lbs. of cyanamid per acre	Experiment I Weeds per sq. ft.*	Experiment II Weeds per sq. ft.*
0	46.8	40.0
200	29.0	5.0
300	15.5	5.4
400	9.2	10.5
600	8.9	1.8
Av. of treated plots	15.7	5.7
L.S.D. .05	11.7	8.8

*Average of 3 replications.

Table IV is a summary of all the experiments discussed above.

Table IV. Averages of all treatments in all experiments on sandy soils using granular cyanamid on corn. 1949, 1950.

Lbs. of cyanamid per acre	% weed control	Bushel increase in yield	Increase in nitrogen
0	0.0	----	----
200	40.2	12.4	.134
400	65.5	14.7	.199
600	70.5	16.1	.211
800	74.5	14.3	.276

Appreciable increases in yields, weed control, or percent nitrogen do not occur above the 400# per acre rate.

Cyanamid when used on a loamy soil is not as effective as when used on a sandy soil. At Rutgers cyanamid has been used on loamy sands, sandy loams, and loams. Results on the loam soils have been indecisive and we have not continued loamy soil treatments with cyanamid to any extent.

The results for 1949, reported in Table V, show the trend found using cyanamid on corn growth in loamy soils. Good weed

Table V. Averages of all treatments in all experiments on loamy soils using granular cyanamid on corn in 1949.

Lbs. of cyanamid per acre	% weed control	Decrease in bushels per acre	Increase in % nitrogen in grain
0	----	----	----
200	19.3	5.5	.007
400	15.1	3.2	.031
600	47.8	7.6	.025
800	43.8	1.5	.046

control was not obtained until relatively high rates of cyanamid were used. Practically no increase in yields or percent nitrogen in the grain resulted from cyanamid treatments on these heavier soils. There was not sufficient data available to explain the differences due to soil type.

SUMMARY

1. The granular form of cyanamid was superior to the pulverized form for weed control and for increasing yields in corn.

2. Mixing cyanamid with the soil was not as effective for weed control as applying it evenly over the surface.

3. The 400# per acre rate was the most practical for weed control and for increasing yields on sandy soils.

4. Granular cyanamid did not give satisfactory weed control or corn yield increases on [illegible] soils where the experiments were carried out on soils of high fertility and low plant population (5,000 - 7,000).

Killing of Leaves and Defoliation of Plants by Chemical Means

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There is a definite need for better methods and chemicals for killing the leaves and defoliating plants. Roses and other nursery stock need to be defoliated before they are placed in storage. It would be helpful if leaves of holly and many other species could be chemically defoliated before being transplanted. Threshing of soybeans could be facilitated if the leaves were killed or the plants defoliated in the field. Increased yields and a better quality of cotton result from the killing the leaves or defoliating the plants in the field.

This report is concerned with killing of leaves and defoliating plants in the field by means of two chemicals, undecylenic (CH_2=$CH(CH_2)_8COOH$) acid and monochloroacetic ($CH_2ClCOOH$) acid. The latter is water soluble, but the former is only slightly soluble. In some cases the triethanolamine salts of these two chemicals were prepared and then used as water solutions. The acid sprays of undecylenic acid were formulated as emulsions. Concentrations used ranged from 0.1 to 3.2 per cent, and the sprays were applied at a high enough rate to insure thorough wetting of the foliage. A wetting agent, Nekal NS at 0.25 per cent, was added to the spray solutions. The sprays were applied with 2-gal. Hudson Junior sprayers, and species used for test objects were rose (hybrid tea), apple, peach, string beans, viburnum, spruce, American holly, lilac, hawthorn, hibiscus, garden bean, and soybean.

Results

Hybrid tea roses were sprayed with 1 per cent and 3.2 per cent concentrations of both chemicals. Also mixtures of equal amounts of the two chemicals were used at the same concentrations. When the rose plants were sprayed with 1 per cent of either chemical or mixtures of the two, 90 per cent of the leaves were caused to fall within 10 days. No injury to the buds resulted from an application of 1 per cent sprays. Regrowth during August and September occurred shortly after the plants were defoliated.

Both chemicals used at 3.2 per cent concentrations killed all the leaves within a week but interfered with leaf fall. Better leaf fall was obtained with lower concentrations than with higher concentrations. Also young tips of the rose plants were either injured or killed when sprayed with 3.2 per cent solutions. Older or dormant axillary buds were not killed with the higher concentrations. Regrowth occurred within three weeks after the plants were sprayed with 3.2 per cent solutions.

Older leaves abscissed more readily than younger leaves near the tip.

The triethanolamine salt of monochloroacetic acid (ClA) was equal in effectiveness to the acid. In contrast, however, the triethanolamine salt of undecylenic acid (UN) was relatively ineffective as compared with the acid.

The mixtures were slightly more effective than either of the acids alone. When applied to plants for the purpose of defoliating, these substances also killed young weeds gnowing under the plants. Crabgrass, purslane, chickweed, etc., were eradicated from the garden though they were not intentionally sprayed.

Apple and peach trees sprayed with 0.5 per cent ClA lost 95 per cent of their leaves without any visible injury to stems or buds. At a 1 per cent concentration ClA killed all the foliage on apples and peaches but not all of the dead leaves dropped. Some stem injury resulted from 1 per cent sprays applied to peach. In contrast with this, UN sprays did not injure leaves of apple or peach. Neither did this chemical cause leaf fall. Table 1 shows the effect of 1 per cent UN and ClA salts when applied to six species of woody plants.

Table 1. Percentage leaf damage and leaf fall after woody plants were sprayed with 1.0 per cent solutions of ClA and UN acids and triethanolamine salts.

Species	ClA				UN			
	Leaf damage, per cent total area		Leaf fall, per cent		Leaf damage, per cent total area		Leaf fall per cent	
	Acid	Salt	Acid	Salt	Acid	Salt	Acid	Salt
Viburnum sp.	50	75	100	0	20	0	0	0
Crataegus sp.	95	0	100	0	95	50	100	95
Hibiscus sp.	75	25	100	0	0	0	0	0
American holly	0	0	0	0	0	0	0	0
Lilac	50	0	0	0	0	0	0	0
Spruce	95	95	0	0	0	0	0	0

The lack if injury induced by 1 per cent sprays of UN in some of the species is of considerable interest since it shows selectivity. For example, spruce trees were entirely resistant to UN, which indicates that the chemical might be used for weeding nursery rows or protecting spruce from competing species. In all probability other important species will show similar resistance.

Another finding of some interest is that apple branches sprayed in May when the tree was in flower indicated that the chemicals might be useful for thinning fruit. When in the pink flower bud stage, the fruit set was reduced 63 per cent over the controls by a 1 per cent application of UN and to 65 per cent over the controls by 0.1 per cent ClA sprays.

When in the calyx stage, the fruit set was reduced by 75 per cent with 0.1 per cent ClA sprays and 70 per cent by a 0.32 per cent UN spray. At these low concentrations there was no evident injury to stems or foliage.

Mature bean plants (var. Tendergreen) were sprayed with a 1 per cent solution of ClA and UN. Both acid and salt formulations of ClA and the acid of UN caused complete killing of leaves. The triethanolamine salt of UN did not kill bean leaves but injured weeds. This is further evidence of selectivity of UN as based on formulation and may have some application in connection with chemical weeding of gardens.

The results of these tests indicate that ClA and UN in the concentration range of 0.5 per cent to 3.2 per cent have defoliating properties. The effectiveness of the substances as defoliants depends upon the species, the formulation, and the concentration. The two substances may be mixed together to increase their effectiveness as related to the number of species affected or to toxicity. In addition to their use as defoliants, results of the tests indicate possible uses as selective herbicides for certain species and as blossom thinners, especially of apple.

PROGRESS REPORT ON THE USE OF 2,4-D AND 2,4,5-T FOR THORN APPLE CONTROL IN PASTURES

By: John VanGeluwe[1], C. V. Flagg[2], R. H. Beatty[3], and E. Lacko[4]

The Situation

With the emphasis being given pasture improvement in the northeast, farmers are becoming increasingly interested in reclaiming land now occupied by thorn apple, brambles, and other small woody plants which grow in the first round of the cycle by which nature returns abandoned land to forest.

The thorn apple, sometimes called hawthorn or white thorn, is of the extremely complex genus Crataegus. This genus, widely disseminated throughout the northeast, is a most serious pasture weed, because it is at once prolific, vigorous and peristant.

Purpose

Because thorn apple (Crataegus) is a major genus to be removed, and because the effectiveness of economical herbicides in controlling this pest is not known, the following trials were set up to determine in a preliminary way:

1) The reaction of Crataegus to 2,4-5-T and a combination of 2,4-D and 2,4,5-T.

2) The concentrations of these chemicals required for kill.

3) An effective and economical method of application.

History of Treated Area

An old pasture approximately 15 acres in size was selected as a good place to conduct these experiments. This area was populated with Crataegus. There were three sections:

1) Virgin growth with specimens up to 10 inches in diameter at base.
2) Cut over 10 to 12 years, with regrowth from stumps and roots 3 to 6 feet in height and trunks at base 2 to 4 inches in diameter.
3) Cut over two years with 6 to 18 inch resprouts from stumps and old root system.

[1,2] G.L.F.Soil Bldg.Serv. a div. of Coop.G.L.F.Exchange,Inc.Ithaca,N.Y.

[3,4] American Chemical Paint Co., Ambler, Pennsylvania

Materials and Date of Application

Weedone Brush Killer 32 is a butoxy ethanol ester formulation of 2,4-D acid equivalent 1-1/3 pounds plus 2/3 pound 2,4,5-T acid equivalent per gallon. Weedone 2,4,5-T is a butoxy ethanol ester formulation containing four (4) pounds acid equivalent per gallon. Oil used was #2 fuel oil. All materials were applied on August 10th to 13th, 1949.

Terminology and Method of Treatment

Foliage - Material applied to thoroughly wet all foliage and scaffold branches

Basal - Stem or basal portion of trunk thoroughly wet, with surplus material running down trunk and onto root crown.

Foliage and Basal - Combination of above two methods.

Equipment

The equipment used consisted of a Kupfer low pressure, gear pump attached to tractor power take-off, oil drum tanks, Kupfer hand boom. Boom head for basal application equipped with two (2) Monarch nozzles, 10 inches apart. For foliage the head was equipped with three (3) Monarch nozzles, 14 inches apart. Monarch #32 and #59 tips were used. Pressures from 40 to 90 pounds per square inch.

Each plot covered an area of approximately 1500 to 2000 square feet, containing between 30 to 40 thorn apple trees per plot. Following are the treatments as applied to the different types of thorn apple.

SERIES I - Located in the area cut over two years ago with re-sprouts from stumps and root system 6 to 18 inches tall.

Plot	Material Used	Spray Mixtures in Gallons			Treatment
		Chemical	Oil	Water	
1	Weedone Brush Killer 32 in water	1	0	100	*Overall + spot
2	Weedone Brush Killer 32 in water	1	0	100	**Spot
3	Weedone 2,4,5-T in water	1	0	100	Spot
4	Weedone Brush Killer 32 in oil and water	1	1	99	Overall + spot
5	Weedone Brush Killer 32 in water	1.5	0	100	Overall + spot
6	Weedone 2,4,5-T in water	1	0	100	Overall + spot
7	Weedone Brush Killer 32 in oil and water	1	10	90	Spot
8	Weedone 2,4,5-T in oil and water	1	1	99	Spot
9	Weedone 2,4,5-T in oil and water	1	10	90	Spot

* Entire surface of ground sprayed
** Sprouted stump only treated, covering all new growth

SERIES II - Located in the area cut over 10-12 years ago with regrowth from stumps and roots 3 to 6 feet tall with trunks 2 to 4 inches in diameter.

Plot	Material Used	Spray Mixtures in Gallons			Treatment
		Chemical	Oil	Water	
1	Weedone Brush Killer 32 in oil and water	1.5	10	90	Foliage
2	Weedone Brush Killer 32 in oil and water	1.5	10	90	Basal
3	Weedone Brush Killer 32 in oil and water	1.5	10	90	Foliage and basal
4	Weedone Brush Killer 32 in oil and water	1	1	99	Foliage and basal
5	Weedone Brush Killer 32 in oil and water	1	1	99	Basal
6	Weedone Brush Killer 32 in oil and water	1	1	99	Foliage
7	Weedone 2,4,5-T in oil and water	1.5	10	90	Foliage
8	Weedone 2,4,5-T in oil and water	1.5	10	90	Basal
9	Weedone 2,4,5-T in oil and water	1.5	10	90	Basal and foliage
10	Weedone 2,4,5-T in oil and water	1	1	99	Foliage
11	Weedone 2,4,5-T in oil and water	1	1	99	Basal
12	Weedone 2,4,5-T in oil and water	1	1	99	Foliage and basal
13	Weedone Brush Killer 32 in water	1	0	100	Foliage and basal
14	Weedone Brush Killer 32 in water	1.5	0	100	Foliage and basal
15	Weedone 2,4,5-T in water	1	0	100	Foliage and basal
16	Weedone 2,4,5-T in water	1.5	0	100	Foliage and basal
17	Weedone Brush Killer 32 in oil	1	40	0	Basal
18	Weedone Brush Killer 32 in oil	1.5	40	0	Basal
19	Weedone 2,4,5-T in oil	1	40	0	Basal
20	Weedone 2,4,5-T in oil	1.5	40	0	Basal

SERIES III - Located in area of virgin growth with specimens up to 18 feet tall and up to 10 inches in diameter				
Plot	Material Used	Spray Mixtures in Gallons		Treatment
		Chemical	Oil	
1	Weedone Brush Killer 32 in oil	1	40	Cut stump
2	Weedone 2,4,5-T in oil	1	40	Cut stump
3	Weedone Brush Killer 32 in oil	2	40	Cut stump
4	Weedone 2,4,5-T in oil	2	40	Cut stump

For the convenience of this paper, all treatments will hereafter be referred to by series and plot number as set forth in the foregoing tables.

Observations

On August 16th, 1949 leaf browning of foliage treated plots was in direct proportion to the amount of oil used in the mixtures. Basal treated plots showed no effect at this date. Observations on November 15th, approximately three months after treatment, showed [illegible] buds for 1950 foliage on plots where foliage was treated with high oil (10 gallons) browned and shriveled. Checks were plump and green. Cambium on all plots appeared unaffected.

MAY 1950

In the growing season of the following year after treatment, none of the sprouts on any of the plots in Series I leafed out. The cambium of sprouts on all plots receiving one (1) and ten (10) gallons of oil were browned. 25% to 30% of sprouts on plots receiving no additional oil had live cambium but were not leafed out.

Basal only treatment in Series II (plots 2,5,8 and 11) leafed out, but slower than checks. Low oil-water foliage treated and foliage-basally treated (plots 4,6,10 and 12) showed partial leafing. Plots treated both foliage and basally showed slightly fewer leaves than plots receiving treatment on foliage only. Plots which were foliage and foliage-basally treated with high oil-water (plots 1, 3,7 and 9) look best with plots receiving basal plus foliage treatment looking better than those where the foliage only was treated. No difference was noted between 2,4,5-T or Weedone Brush Killer 32.

Plots basally treated with oil only as the carrier (plots 17, 18,19 and 20) leafed out about the same as low oil-water and foliage treated plots (numbers 4,6,10 and 12).

JUNE 1950

In Series I, 25% to 30% sprouts on plots where water only was used as the carrier were leafed out. Low oil plus water carrier plots (4 and 8) showed new shoots sprouting from base of old stumps. High oil plus water carrier (plots 7 and 9) appear completely dead - cambium of old stump dead - bark slufing off. Still no observable difference between 2,4,5-T and Weedone Brush Killer 32.

In Series II basally treated plots (2,5,8 and 11) leafed out nearly normal, showing slight distortion on some leaves. Small seedlings not leafed with cambium brown to base. Low oil and water carrier on foliage alone and foliage plus basal treatments, observed as follows:-

a) Plots 4 and 6 showed 5% - 10% distorted foliage.

b) Plots 10 and 12 leafed nearly normal. Only slight distortion of leaves. Foliage plus basal applications (plots 4 and 12) slightly better than foliage alone (plots 6 and 10). It appears that, at this low oil level, Weedone Brush Killer 32 (plots 4 and 6) is superior to Weedone 2,4,5-T (plots 10 and 12).

c) Plots treated with water as the only carrier, foliage plus basal application (plots 13 and 14) show good control with plot 14 showing effect of increased dosage. 2,4,5-T showing little control at this date (plots 15 and 16).

d) With oil as the only carrier in basal treatments only, (plots 17,18,19 and 20) leaves which were green earlier are beginning to brown at this date. Again, increased dosages appear better.

Series III all stumps in plots 1 to 4 appear dead with bark sluffing away from stumps. Check showing 6 inch sprouts at this date.

AUGUST 1950

In Series I practically no control of thorn apples was obtained when water alone was used as a carrier as a foliage spray (plots 1,2,3,5 and 6). In all plots kill was increased by the addition of oil. Control on plots with high oil (10 gallons) plus 90 gallons water carrier (plots 7 and 9) being better than low oil (1 gallon) plus water (plots 4 and 8).

Roots observed by pulling stumps showed more browning or killing of roots when 2,4,5-T was used alone as a foliage spray (plot 8) as compared to the combination of 2,4-D and 2,4,5-T (plot 4).

Series II, the combination of 2,4,5-T and 2,4-D appeared to give superior control at this date from combination foliage and basal applications in water alone (plots 13 and 14) as compared to 2,4,5-T alone at nearly equal concentrations of total acid (plots 15 and 16).

Basal treatment only, with water as a carrier, with either high oil (10 gallons) or low oil (1 gallon) showed poor control as compared to the foliage spray from "above ground" observations at this date.

Root kill with 2,4,5-T alone in high oil (10 gallons) as a foliage and basal spray (plot 9) was definitely superior to Weedone Brush Killer 32 in high oil (10 gallons) applied as foliage and basal spray (plot 3) but Weedone Brush Killer 32 showed definite browning as compared to untreated checks.

Basal treatments in oil alone of 2,4,5-T and the combination of 2,4-D and 2,4,5-T (plots 17,18,19 and 20) show the most discoloration and root kill at this date.(one year after treatment) as compared to equal concentrations of the same materials applied in water as an overall application (plots 13,14,15 and 16). 2,4,5-T in either method of application (plots 15,16,19 and 20) gave superior root discoloration and kill as compared to the combination 2,4-D and 2,4,5-T (plots 13,14,17 and 18).

Series III showed no recovery of any treatments at this date.

Conclusions

1) Foliage applications in a high oil-water carrier appears to give less leaf development and more leaf distortions as observed early the following growing season as compared to basal treatments in an oil carrier alone. However, the basal applications, which start with more growth development in the early spring, show progressive withering and dying as the season advances.

2) The use of 10 gallons of oil in 100 gallons of spray in all cases increased the effectiveness over one gallon of oil in 100 gallons of spray throughout the season.

3) Cut stumps treated with 2 ,4-D and 2,4,5-T combinations and 2,4,5-T alone did not resprout, but do not show the evidence of translocation present when the same materials and concentrations are applied to standing Crataegus, and some species show evidence of resprouting from the roots.

4) Basal applications in oil at this date of application appeared to give better translocation to the root system than the same rates of application applied to the foliage in water mixtures as observed one year after application in uncut standing Crataegus.

5) As the amount of 2,4,5-T was increased, regardless of method of application, there was evidence of greater translocation to the root system in uncut standing Crataegus.

6) Further work is now underway in greater detail in this same area with the same genus and the same commonly found species.

Progress Report on Control of Woody Weeds in Winter

by A. M. S. Pridham
Cornell University

Treatment of brush along roadsides in 1947 and 1948 failed to indicate any contról of *Fraxinus americana* from foliage sprays with 2,4-D in amounts up to 4.8 pounds per acre.

The use of basal spray treatment during the dormant season was begun in January 1949. Commercial formulation of 2,4-D and of 2,4,5-T were diluted with No. 2 fuel oil and swabbed on the trunk of 5 to 10 foot seedlings of *Fraxinus americana*. Check treatments using No. 2 fuel oil gave no mortality. 2,4-D proved to be less consistant than did 2,4,5-T in killing ash. The highest mortality ocurred when 2,4,5-T was applied to trunks ringed by frilling. Applications made to a narrow two inch band of bark without mechanical injury were not effective.

The tests reported at this time cover applications made during the period, January to March of 1950. Two series of treatments were made: one on seedling and the second on 4 to 10 inch caliper trees.

Young plants of *Fraxinus americana* in a heavy stand averaged 1.75 plant per square foot. Plots 10 x 10 foot were marked off and separated from adjacent plots by a two foot buffer strip. There were four plots in each treatment. In one plot the brush was cut back to six to eight inch stubble; the remaining three plots received basal spray over the lower six to eight inches of stem by covering the whole ground surface at a rate of 60 gallons per acre.

In October a two foot area was located at random in each plot. Plants were dug up and examined. The results are summarized in the following tables.

Table 1—Mortality (top and root dead) as per cent of stand in seedling *Fraxinus americana* 5 to 10 feet following overall basal spray treatment during late winter. Figures average of 9 plots except control which averages seven plots.

Fuel Oil Spray Mixture	Tops cut one month before spray	Plants not cut back
Control -- no spray	0.00	0.00
Fuel oil only	0.00	0.00
2,4-D oil mixtures	4.00	17.00
2,4,5-T oil mixtures	39.00	64.00

Table 2--Mortality (top and root dead) as per cent in seedling *Fraxinus americana* 5 to 10 feet following application of 2,4,5-T in fuel oil.

Fuel Oil Spray Mixture	Tops cut one month before spray (single plot)	Plants not Cut back (Av. 3 plots)
Untreated	60.00	0.00
#2 Fuel Oil	0.00	0.00
Oil + 2,4,5-T (Dow) 9124		
1 : 1	33.00	37.00
1 : 3	50.00	77.00
1 : 9	25.00	50.00
Oil + 2,4,5-T standard Agricultural Chemical (Methyl esters Isopropyl esters)		
1 : 1	100.00	93.00
1 : 3	50.00	87.00
1 : 9	33.00	40.00

Experience noted above, in which data are based on discolored roots and dead tops of young plants of *Fraxinus americana*, following basal spray treatments in late winter would indicate:

1. That where the spray mixtures are applied as over all ground spray at a rate of 60 gallon per acre, 2,4,5-T is somewhat effective as an herbicide.

2. That ineffective treatments include (1) cutting back brush to 6 or 8 inches as normally practiced, (2) use of fuel oil as a herbicide.

3. That herbicidal applications to uncut brush are at least equally as effective as those made to cut over brush.

The second series of tests conducted during 1950 were made on trees of *Fraxinus americana* ranging in size from four to eight inches caliper at breast height. Treatments were made in January. Each herbicide was applied to a frilled ring on 15 trees and also applied in a four to six inch band on ten additional uncut trees. Trees were examined during the summer and final observations conducted in November when bark was removed and the cambium examined a foot above and below the point of herbicide application. The results are stated in Table III as the percent of trees showing serious injury (at least 50% of cambium dead) in November.

Table III--Serious injury (50% ring dead) to the cambium of 4-8 inch D.B.H. *Fraxinus americana* following application of herbicides during January 1950.

Herbicide Applied from Oil can	Herbicide Applied to Frilled Ring - 15 trees	Herbicide applied directly to bark 10 trees
Control -- No Herbicide applied	0.0	0.0
Ammate 1 lb. per pint	52.0	0.0
2,4-D Tri-ethanal amine Stantox 64	13.0	20.0
2,4-D butoxy ethanal amine American Chemical & Paint	20.0	16.0
2,4,5-T Mixture methyl-isopropyl esters Standard Agric. Chemical	53.0#	0.0*

The treatment of large plants of *Fraxinus americana* would indicate the following:

1. Frilling the bark in a ring around the trunk did not appear to kill the trees.

2. Ammate and 2,4,5-T appears to have greater herbicidal value than does 2,4-D for control of ash.

None of the trees produced leaves. Many of the upper branches were brittle and broke off readily, however cambium was still green in local areas.

* All trees showed apparently dead tissue in band where 2,4,5-T was applied also the trunks showed abnormal increase in girth at point of application.

3. Response to application of herbicide is more marked when the chemical is applied to the frill but response was noted to both 2,4-D and 2,4,5-T applied to the uncut bark.

4. Response to Ammate was confined in these experiments to application made to cut surfaces.

SUMMARY

Seedling *Fraxinus americana* up to an inch in diameter and 10 feet in height have been killed by basal spraying during the late winter. For this purpose a spray of 2,4,5-T mixed with oil in the ratio of 1 volume of 2,4,5-T (approximately 40%) to 3 volumes or less of fuel oil gave good results when used as an over all spray at 60 gallons to the acre.

Cutting of small brush did not enhance the effectiveness of 2,4,5-T, but does appear to be of value for efficient herbicidal action on plants of four inch D.B.H. and larger.

Effectiveness of 2,4,5-T seems greatest with mixtures of the methyl and isopropyl esters.

The author wishes to acknowledge the cooperation of the several chemical companies who have supplied materials in support of this and other projects in brush control. In the present case, materials were supplied by

Standard Agricultural Chemical Co.
American Chemical & Paint Co.
Dow Chemical Co.
Food and Machinery Corp.

REPORT ON THE WHDH BRUSH ELIMINATION PROJECT OF THE BOSTON HERALD TRAVELER CORPORATION

Frank E. Egler[1]

SUMMARY. The Project, initiated in November 1949 and planned to continue indefinitely, involves a 48-acre site in Needham, near Boston. The research is designed according to the author's system of Conversion from present brushland to various kinds of grasslands and shrublands that will require low maintenance costs, with emphasis on dormant knapsack basal spraying. As a public demonstration project, it is receiving the cooperation of chemical and contracting corporations and government agencies. Some of the spraying treatments already give indication of a high percentage of rootkill, at low per-acre costs for certain brush densities; and new stable plant covers are beginning to appear.

Description of the Site. The transmitter of radio station WHDH, a subsidiary of the Boston Herald Traveler Corporation, is situated at Needham, west of Boston. The area was a red maple swamp, developed on eight feet of muck in an old lake basin. Three 400-foot transmission towers, a radiating system of ground wires covering 48 acres, and access roads were constructed in 1948. Broadcasting efficiency demands the absence of tall brush over and near the ground wires.

History of the Site. The forest was cut in the spring of 1948. Stumps immediately sprouted, and in August of 1948 reached such a height that they were blanket-sprayed by a commercial concern with a 2,4-D compound, resulting in immediate foliage burn. Growth in the spring of 1949 appeared unaffected by the chemical, and the entire area was blanket-sprayed a second time with a defoliant. The resultant foliage-burn was followed in a few weeks by apparently normal regrowth. As judged by existing control plots, these two early sprays have left no continuing effects on the woody plants.

Plan of Present Project. In the fall of 1949, the 48-acre tract was divided into 24 areas, each of which was subjected to a different treatment involving: (a) conversions to grassland and to low shrubland; (b) heavy ester sprays of 2,4,5-T alone, and mixtures of 2,4-D and 2,4,5-T (in ratios of both 1:1 and 2:1) (c) at concentrations of 5% and 10% acid equivalent (assuming the figure on the commercial labels as an A.E. percentage by volume); (d) with both water and oil as carriers. Commercial formulations were supplied by the Dow Chemical Company and the American Chemical Paint Company, with a small quantity from the Pittsburgh Agricultural Chemical Paint Company. Knapsack selective basal spraying was begun December 5, 1949, and finished April 4, 1950, by radio station personnel untrained in this type of work - except for 2.6 acres blanket-power-sprayed by the Bartlett Tree Expert Company in July, and 1.3 acres selective-dormant-basal-sprayed in August. Application was with 3-gallon knapsack sprayers, and the lowermost 18 inches of the shoots were thoroughly wetted.

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[1] Consulting Vegetationist, Norfolk, Connecticut.

Available Data. The original 1948 and early 1949 blanket sprayings have left no visible effects on the control plot. Not enough time has elapsed for indicative results from the July and August sprayings of 1959. The 1949-1950 dormant selective sprayings have resulted in the truly striking alterations - now well known to workers in this field - when a solid sea of tree sprouts literally vanishes, leaving a low cover of herbs and grasses, and so little evidence of the tree shoots once there that it is difficult to reconstruct a mental image of the woody growth that had been present. Shootkill progressed irregularly through the 1950 growing season, depending on: (a) the recency of the basal spraying; (b) the concentration of the esters; and (c) the carrier. The stronger concentration and the oil carrier gave the quicker results. Plants either did not leaf out at all, or the buds burst and shoots developed to varying degrees before above-ground parts died back to the ground.

Final field observations this season were made in mid-September, from which the following tentative observations can be drawn:

1. A certain number of red maple plants (less than 25% on any one plot) had sent up one or a few feeble new shoots. Based on data obtained elsewhere, these may die during the coming winter without further respraying. Rootkill is probable for all the others that had been killed to the ground.

2. "Misses" involved not only a few that had been skipped by accident, but ones that were under snow at the time of spraying, or that were avoided because deep water either covered them or made it difficult to reach them. This season's additional growth will permit most of those to be seen and sprayed on the next treatment.

3. With the solutions used, no difference is yet apparent between the 2:1 and the 1:1 D-T solutions.

4. With the solutions used, no difference is yet apparent between the D-T solutions, and the T alone.

5. At the 5% A.E. level, oil as a carrier is definitely superior to water, at this time.

6. All 10% solutions showed superiority to the 5% solutions in apparent rootkill.

7. At this time, a 5% D-T solution in oil would appear to be the lowest-cost treatment, for the results obtained. Lower percentages are probably effective.

8. Cost data for this first spraying can be computed by the reader from the following basic information (in which is not included all overhead, equipment, and incidental expenses of a fully commercial job):

For producing 12.9 acres of grassland, there was used an average of:
16.1 gallons of solution per acre, and
9.6 man-hours per acre, involving portal-to-portal time from and to the transmitter site adjacent to the 48-acre tract.

For producing 30.0 acres of shrubland, the comparable figures are:
6.4 gallons of solution per acre, and
5.1 man-hours per acre.

In terms of a 5% A.E. D-T solution in oil, this would require .75 gallons of a commercial formulation carrying .43% A.E., and about 4.25 gallons of a cheap fuel oil, per acre.

9. Final data on rootkill from these sprays are not yet available, and consequently no respraying is being done this winter of 1950-51, nor is there

enough brush left to interfere with the needs for broadcasting to demand re-spraying.

10. Evidence of future low Maintenance costs - the most important phase of this research Project - are already appearing. Some plants, previously rare, are rapidly increasing their coverage, mainly several swamp grasses, broad-leaved herbs, a mat-forming dewberry, skunk cabbage and cattail. This year an annual fireweed was extremely abundant, but it is not expected to remain common. Small spots that had been bare, especially in the west of the tract, are now solidly covered with red maple seedlings, forming a closed mat some 12 inches high. Other red maple seedlings, two years and older, are scattered irregularly over the entire site. The occurrence of tree seedlings appears at this time to be directly correlated with the presence of spots that had been bare of all plants at the time of initiation of the Project.

Future Plans. The plots sprayed in the winter of 1949-50 will not need retreatment until the late summer of 1951 or the winter of 1951-52, at which time unkilled plants, "misses", and plants previously there but too small to be sprayed, will be treated.

Small plots will be laid out on critical kinds of different plant covers, for continuing observations on their spread, stability, and especially their resistance to reinvasion by unwanted trees and shrubs.

Twelve new 6-foot wide grassland transects will be laid out between the present shrubland tracts, for conversion to grassland by basal spraying, using new chemicals and combinations of chemicals.

Evaluation of Data. Information available this first year from the Project are to be evaluated in terms of (a) effectiveness of treatment per species; and acreage costs.

a. Red maple formed 95% of the trees treated, and data for other trees are not yet indicative. Observations on root kill of the several swamp shrubs will be made next spring. Basa l-spraying for red maple appears to give a high percentage of rootkill, with a minimum of la bor materials and equipment, and with a minimum of damage to surrounding plants and adjacent areas. This kill of red maple should be duplicatable elsewhere.

b. Tree shoots on the 48-acre tract, though they originally appeared to blanket the entire site at a distance, averaged 50-75% coverage at a height of six feet, and these were aggregated into clumps from the original stumps. This brush had been sufficiently dense to require blanket-spraying with power equipment. It is difficult to compare this brush density with that of other lands in the Northeast, such as the rightofways of public utilities, though it is probably fair to imply that it represents an average for large acreages, which in themselves can vary from very dense to light brush and open lands. In all cases, the final saving in dollars is not to judged solely by the expense of the initial treatment, but in terms of the plants allowed to remain, which in themselves are factors than can prevent reinvasion of unwanted plants.

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THE UNSUITABILITY OF CERTAIN GRASSLANDS AS RIGHTOFWAY VEGETATION COVER

Frank E. Egler[1]

SUMMARY. Grasslands, as developed by blanket spraying with chemical herbicides, on botanical grounds are generally a poor investment by comparison with other techniques. Not only may blanket spraying involve a more expensive initial conversion cost in some instances, but plant-sociologic evidence indicates that such grasslands are open to invasion by certain tree seedlings, requiring resprayings in the future that would otherwise be unnecessary.

Pre-1945. The management of vegetation on the rightofways of utility corporations had been, until about 1945, solely a matter of mechanical cutting, using hand labor and axes, of those woody plants too tall for reasonable inspection and maintenance of the lines. The botanical problem in those days was relatively simple. The hand cutting - like one's morning shaving - destroys no root systems; it is followed immediately by resprouting, which in turn demands recutting. On the rightofways, this practice has had almost no effect in changing the botanical composition of the plant cover. In many parts of the country, the amount of brush-to-be-cut gradually increases through the years, due to a greater number of sprouts per crown, and to additional sprouting from terminal distal portions of the root systems, as in aspen and sumach. The costs per acre of this practice tend, therefore, to increase slightly (Fig. 1).

Post-1945. The advent of chemical herbicides for rightofway use has put a powerful tool in the hands of maintenance engineers, a tool which, in the opinion of the author, has been used with a bull-in-the-china-shop vigor, and with little grasp of the refined techniques it makes possible, and which could significantly reduce operating costs in the future.

Grassland vs. Shrubland. The relative merits of grasslands for rightofway cover, as opposed to shrublands - assuming one has a choice between them - is a problem that should be decided by scientific research in terms of costs per acre per year. Yet I feel that the matter has too often been decided in favor of grasslands, more on the basis of supposed chemical effects, photogenic appeal, and short-term costs. Let us examine some of those points:

Supposed chemical effects. The chlorophenoxy herbicides are known to effect broadleaved plants, both herbs and woody species; but they are relatively ineffective on grasses. Premature judgments on this selective killing ability made one reach the conclusion that overall blanket sprays would result in the elimination of all woody plants and coarse herbs, and allow the development of a pure grassland, like one's lawn unmown. If this conversion were actually possible, I believe that such a grassland might be the cheapest and most desirable cover for rightofways, on a short-term basis. No one who has used these chemicals however has not been brought to realize that these woody plants least liable to rootkill are certain unwanted trees, such as apples, ashes, hickories,

[1] Consulting Vegetationist, Norfolk, Connecticut.

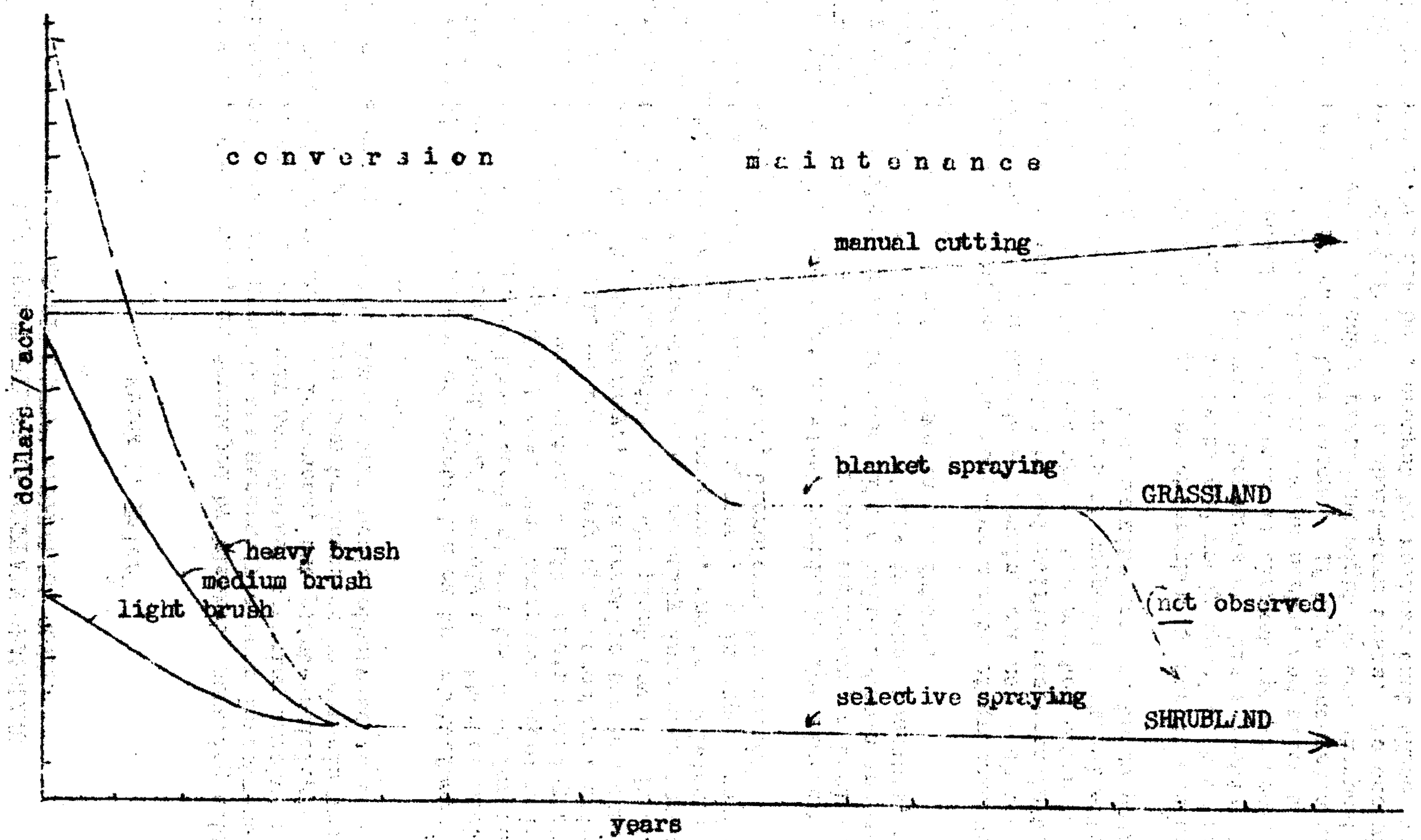

Figure 1. Diagram showing generalized relationships for long-term costs of brush control on large acreages by: (a) manual cutting; (b) blanket spraying; and (c) selective spraying.

oaks, which, surviving, soon turn the shrubless grassland into a young forest stand. Respraying becomes necessary, until the trees, by one means or another, are killed. The herbicidal effects of chemicals now available are not such as to produce a grassland in a single spraying, in most cases and at a reasonable cost.

The photogenic appeal. Another aspect of contemporary interest in grasslands as rightofway cover is the very understandable and excusable comprehension of the subject by men, regardless of their technical abilities along other lines, to whom all plants are classified either as "grasses" or "brush". Grass will not grow up tall; brush does grow up, and has to be cut. It is a problem in basic botany to distinguish between a brush of maples oaks and ashes which requires costly periodic cutting, and a very similar appearing brush of low blueberries, huckleberries and sweetfern which, simply, does not grow up. This problem is not aided by the fact that a grassland is highly photogenic, producing a picture which is pleasing to the eye and coveted by the advertiser, especially when it is an "after" and the "before" was a brush of tree sprouts. Difficult, if not impossible, is it to give a selling argument on a photo of a low shrub cover, which to an untrained eye looks precisely as it did when the tree sprouts dominated it. Photogenic appeal, of a grassland, is misleading to the highest degree.

Relative c o n v e r s i o n costs. Not enough data are yet available to evaluate fairly the relative costs of conversion of present brush covers (a) to grassland by blanket spraying, or (b) to low shrubland by selective spraying. Costs vary markedly depending on the amount of unwanted brush present. I have seen tracts where the relatively few tree sprouts could have been removed more cheaply by knapsack spraying than by the power spraying being done. Conversely, there are some tracts of extremely dense tree sprouts where so few wanted low-shrubs are present that the higher cost of selective spraying might not outweigh the future values of those few low shrubs. On the whole, however, the sum total of rightofways known to the author are such that in his opinion selective removal of unwanted trees in a significant number of cases would both permit lower conversion costs, and result in lower future maintenance costs, than the blanket sprays now customary.

Relative m a i n t e n a n c e costs. After "conversion" (the rootkilling of all unwanted trees and shrubs) is completed, "maintenance" (the rootkilling of trees and shrubs reinvading by seeds, and by underground roots from off the rightofway) takes over. It is in planning for the lowest possible future maintenance costs that my own research interest chiefly lies. It is here that the knowledge of the field botanist is requisite. Different plant communities differ extraordinarily in their ability to cover the land "tightly" and to form a cover which definitely resists, or prevents, the reinvasion of trees (often contrary to academic ecologic theory). Each species is an individual case, the value of which in this connection can be told only from field observations. Furthermore, the "tightness" of a cover of a species can vary from site to site, and from region to region, making impossible any single listing of the species for this purpose. Barring certain exceptions, all such permissible rightofway covers can be grouped as "grasslands" (plants of a grass-like life-form) or shrublands (scattered low shrubs and coarse herbs). The differing efficiency of these two cover-types in keeping out reinvasion by unwanted trees is such that every utility corporation interested in long-term costs should give the matter critical consideration, even though their policy to date has been one of "cut, when necessary".

It is not the purpose of this paper to give actual data on the relative persistence of grasslands and shrublands. They appear in the botanical literature; they have been investigated by the author at Aton Forest since 1927; and they have been interpreted by him in various parts of this and other countries. Certain generalizations are in order:

Shrublands. A potential shrubland is frequently now present on rightofways, and would "take over" on the selective elimination of the unwanted trees. These desirable shrublands (but not all shrublands), in which a dozen shrub species half a dozen fern species and possibly two dozen coarse herbs appear to be most prominent in the Northeast, have a remarkable ability to resist invasion by over a hundred kinds of other woody plants. On a tract at Aton Forest, Norfolk, the total reinvasion of ten years has not been sufficient to require a respraying were the area on a rightofway (article in press). Other covers known to the author for 25 years have not changed enough in that time to warrant a spraying! Such covers as these (which are completely destroyed by blanket sprayings) are or could be developed on rightofways. Once destroyed, the author has not seen them return to the land.

Grasslands. The situation with most upland grasslands (though there are exceptions) is such that the greater dollars/acre/year maintenance cost cannot be overlooked by utility corporations. It is true that a heavy sod and mat of dead grass is a deterrent to invasion by a large number of woody plants. On the other hand, one large hole in a dike is as critical as several small holes. It remains a botanical fact that in the common types of grasslands (Andropogon, Poa, Agrostis, Anthoxanthum, Dactylis, Phleum, Agropyron) a few tree species can and do invade with such abundance as to affect markedly the future maintenance costs. For example, both white pine and white ash have been observed to invade grasslands in such abundance that they form at least locally a 100% coverage when they attain a height of two feet. No accurate prediction can be made as to the rapidity of such invasion, for it depends not only on the occurrence of a good "seed year", but on moisture, temperature and other conditions suited to the growth of the seedling.

In conclusion, the existing botanical evidence indicates that selected shrublands can be maintained at lower cost through the years than grasslands, and consequently deserve to be preserved when they already exist on the land, even if such preservation involves a slightly higher conversion cost. Contrary botanical evidence has not yet come to the attention of the author. He would welcome such information from any reader.

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RESPONSES OF QUACK GRASS (*Agropyron repens*) TO TREATMENT WITH MALEIC HYDRAZIDE[1]

William E. Snyder, Cornell University

Introduction

Since nursery stock often remains in a field for five or more years, a heavy infestation of weed grasses may occur if the area is infrequently cultivated. Before replanting with small nursery stock these areas should be made relatively free of such weeds so that reinfestation can be kept under control by spot chemical treatment and/or cultivation.

It has previously been reported that by the use of herbicides, quack grass (*Agropyron repens* (L.) Beauv.) can be reduced effectively to a level which will permit continued control (1). Sodium trichloroacetate and ammonium thiocyanate can be used with considerable success against quack grass. A disadvantage of sodium trichloroacetate is that foliage application will not kill the rhizomes and new shoots will develop. Ammonium thiocyanate is also a contact type of herbicide, is costly, and is corrosive to metal spray apparatus and containers. Following application of ammonium thiocyanate in quantities sufficient to control quack grass the area may be rendered unfit for planting the following season.

Zukel (2) has recently reported that application of relatively small quantities of maleic hydrazide to young foliage will kill the foliage and inhibit the formation of new rhizomes. Application to older foliage inhibit top growth, flowering, and rhizome formation.

The experiments reported here were designed to test various methods and rates of application of maleic hydrazide in order to obtain information on which to base field trials for the control of quack grass.

Materials and Methods

The rhizomes of quack grass used in these experiments were dug from a heavily infested field. The rhizomes were washed free of soil and selected for uniformity of size and appearance. Sections of rhizomes were made five to seven centimeters in length and each contained three nodes with no actively growing buds. Ten such segments were planted in a #10 tin can at a depth of 2½ inches in sterilized potting soil. Holes had been punched in the bottom of each container to allow for drainage. After the rhizomes were

[1] Appreciation is expressed to Mr. Jewett Hamilton and Mr. Robert Gregory for their assistance in conducting these experiments.

planted, the cans were placed in the greenhouse and the soil in each container was thoroughly moistened. The experiments were conducted during the Spring and Summer, 1950 and were under greenhouse conditions during the experimental period.

Maleic hydrazide and Antarox A200 were supplied by Naugatuck Chemical Division, United States Rubber Company. The maleic hydrazide was supplied as a solution containing 30% of the active material in the form of the diethanolamine salt. Dilutions were made on the basis of weight of the active material. The sodium trichloroacetate was supplied by Standard Agricultural Chemicals Company. All solutions were made to contain .03% Antarox A200 as a wetting agent. All references to the concentration and rates of maleic hydrazide and sodium trichloroacetate refer to the quantity of active material present.

The chemicals were used as a preemergence application to soil containing inactive rhizome segments or as a foliage application to young plants. In all cases the soil applications were made the day after the rhizomes were planted. Foliage sprays were made 17 to 23 days following planting, and at the time of treatment the foliage had reached a maximim height of fifteen centimeters. Foliage applications were made under simulated field conditions and with a knap-sack sprayer equipped with CO_2 cylinders and regulated to maintain uniform pressure.

In several of the experiments, at the end of a given period, the rhizomes were replanted in uncontaminated soil to determine the effectiveness of the various treatments in preventing new growth from the rhizomes. Before replanting, the rhizomes were washed free of soil and the fibrous roots and stems were removed. The stems were removed one centimeter above the first node since new rhizomes may arise above this node.

The latin square experimental design was used and each experiment contained from four to six replicates depending upon the number of experimental treatments. All data were analyzed statistically and are presented as averages for the various treatments.

Experimental Results

Effects of soil application.—In two experiments a constant volume of solution (100cc) containing various concentrations of maleic hydrazide was applied to soil containing the segments of inactive rhizomes. The results of the first experiment are presented in Table 1 and show that the application of .01% maleic hydrazide at a rate of 5.8 pounds per acre resulted in a significant decrease in the number of stem breaks and new rhizomes formed, the average height and dry weight of stems, and in the length and dry weight of rhizomes. At a concentration of .05% (29 pounds per acre) there was slight growth activity, but at .10% (58 pounds per acre) there was a complete suppression of growth. The responses to .05 and .10% were not significantly different, however both differed significantly from the .01% treatment, except for the dry weight of rhizomes.

TABLE 1

Effect of different concentrations of maleic hydrazide on the growth of ten 3-node segments of quack grass rhizomes. Applications were made to the soil 24 hours after planting. Data is based on the average of five replicates and was taken 49 days after treatments.

	Water Control	% maleic hydrazide * .01	.05	.10	.25	Least Significant Difference
No. of rhizomes with breaks	9.8	6.6	0.2	0.0	0.0 '	.7
No. of rhizomes with new rhizomes	8.6	2.4	0.0	0.0	0.0	.9
No. of tillers	58.4	30.6	0.4	0.0	0.0	6.7
No. of new rhizomes	15.6	4.0	0.0	0.0	0.0	1.7
Ave. length of tillers in cm.	49.5	30.5	0.5	0.0	0.0	2.4
Ave. length of new rhizomes in cm.	8.1	2.5	0.0	0.0	0.0	.7
Dry weight of tillers in gm.	13.7	2.6	0.0	0.0	0.0	1.6
Dry weight of all rhizomes in gm.	7.2	2.1	1.1	1.1	1.2	1.5

* Pound per acre equivalents: .01% — 5.8; .05% — 29; .10% — 58; .25% — 145.

' Dry weight of two short breaks less than 10 mg.

In a second series, the concentrations of maleic hydrazide ranged from .025 to .10%. The results (Table 2) show that .025% (14.5 pounds per acre) significantly reduced growth but did not completely suppress it. Concentrations of .05% (29 pounds per acre) resulted in a slight activity of stem growth but no rhizome production. Applications of maleic hydrazide at concentrations of .075 and .10% completely inhibited growth. Sodium trichloroacetate applied at a rate of 100 pounds per acre resulted in a complete suppression of growth.

Sixty-three days after the treatments, the rhizomes were replanted in uncontaminated soil. A large number of new shoots developed in the control group. Groups receiving .025% maleic hydrazide and sodium trichloroacetate produced a few new stems. Maleic hydrazide in concentrations of .05 to .10% completely suppressed new growth.

TABLE 2

Response of ten 3-node segments of inactive rhizomes of quack grass to soil treatment of herbicides applied 24 hours after planting. Data are averages of six replicates.

Treatment	63 days after initial treatment		No. of new stems produced 45 days after replanting rhizomes
	No. of new stems produced	No. of new rhizomes produced	
Control	47.7	21.2	103.3
Percent maleic hydrazide*			
.025	5.7	1.7	2.0
.05	0.2	0.0	0.0
.075	0.0	0.0	0.0
.1	0.0	0.0	0.0
Sodium trichloroacetate 100 #/A	0.0	0.0	0.3
Least significant difference 1%	2.0	2.0	1.9

* Pounds/acre equivalents: .025% — 14.5; .05% — 29; .075% — 43.5; .10% — 58.

A third experiment was designed to compare the effectiveness of equal quantities of maleic hydrazide applied at two different concentrations. The results (Table 3) show that applications of 29 pounds per acre at concentrations of .05 and .10% effectively reduced the growth from quack grass rhizomes. Applications of 58 pounds per acre at both concentrations, as well as sodium trichloroacetate at 100 pounds per acre, were significantly more effective in reducing the number and length of shoots than were the 29 pound per acre applications. Slight, but not significant, growth of rhizomes was obtained at the 29 pound per acre rates. Applications of solutions containing .1% maleic hydrazide were not as effective in preventing growth as .05% applications. This is believed to have resulted from a more uniform distribution of the maleic hydrazide by the larger volume of liquid applied in the .05% treatments.

Replanting the rhizomes 57 days after the initial treatment indicated a significant inhibition, but not complete suppression, of shoot development from rhizomes treated with maleic hydrazide and

Table 3

Comparison of Rate and Quantity of Application on Growth of Quack Grass.
Herbicides added to Soil Twenty-Four Hours After Planting
Ten 3-Node Segments of Inactive Rhizomes in each of Six Replicates.

57 days after Treatment	Control	Maleic hydrazide .05% 29#/A	.05% 58#/A	.1% 29#/A	.1% 58#/A	Na-T C A 100 #/A	Least Significant Difference 1%	5%
No. of Stems	48.7	2.8	0.0	4.5	0.3	0.0	4.1	2.7
Length of stems in cm.	32.3	16.5	0.0	14.6	0.5	0.0	5.0	3.6
No. of new rhizomes	22.8	0.8	0.0	1.8	0.0	0.0	3.0	2.2
Length of rhizomes in cm.	9.8	0.8	0.0	0.1	0.0	0.0	10.7	7.9
No. of new stems 45 days after re-planting in fresh soil.	108.7	.5	.7	.8	.8	.3	6.8	5.0

sodium trichloroacetate. All treatments produced significantly less growth than the control group, but the difference between treatments were not significant.

In order to ascertain the retention of toxic properties of maleic hydrazide remaining in the soil, seed of red kidney bean and golden bantam corn were planted in soil which had been treated with various quantities of maleic hydrazide 49 days previously. Continued toxic effects were noted in soil treated with .05 to .25% (29 to 145 pounds per acre) of maleic hydrazide. This was indicated by the number of seed germinating, the time required for germination, and the subsequent growth of the seedlings. Bean seeds planted in soil treated with .25% maleic hydrazide failed to germinate, however, the corn germinated. The corn seedlings were killed within one week. In the soil previously treated with .1% maleic hydrazide, some seedlings became chlorotic, turned brown, and died, while others remained green, grew slowly, and possessed abnormally shaped leaves. Compared with the control group, there was a marked stimulation of germination and early growth of the corn planted in soil which had been treated with .01% (5.8 pounds per acre) maleic hydrazide. After four weeks this stimulation persisted but was less marked.

Effects of foliage application.--In the first experiment, maleic hydrazide was applied to the foliage in a series of concentrations ranging from .125% (5 pounds per acre) to 1.50% (60 pounds per acre). The data (Table 4) show that .125% maleic hydrazide was effective in reducing the number and length of new rhizomes formed, but that the number and length of stems were not significantly different from the control. At .25% (10 pounds per acre) there was a marked reduction in the number and length of stems and rhizomes produced. Concentrations of .50% and higher (20 pounds per acre and more) not only prevented the formation of new shoots and rhizomes, but also brought about death of most of the stems present at the time of application. Differences between the stronger concentrations (.50 to 1.50%) were not significant.

Eighty-four days after the spray was applied the rhizomes were replanted in uncontaminated soil. New shoots developed in the control lot and in those treated with .125 and .25% maleic hydrazide, but not in lots treated with .50 to 1.50%.

Forty-five days after the rhizomes were replanted, the material was examined to observe the source of these new shoots. In general the new shoots arose from the new rhizomes, however, an occassional shoot arose from the original segments of quack grass. Many of the original rhizome segments of the groups treated with .50 to 1.50% maleic hydrazide were decomposing.

Table 4

Effect of Foliage Application of Maleic Hydrazide on Growth of Quack Grass.
Treatments made When Foliage was Ten cm. in Length
Data Based on Six Replicates, Each Replicate Contained ten 3-node Segments of Rhizomes.

84 days after treatment	Con-trol	Percent maleic hydrazide*					Least Significant difference	
		.125	.25	.50	1.00	1.50	1%	5%
No. of Stems Percent of original Number	401	393	143	4	6	0.0	52	37
Length of stems in cm.	37.1	32.7	31.2	6.0	2.4	0.0	10.1	7.2
No. of new rhizomes	46.6	13.0	7.0	0.4	0.0	0.0	5.2	3.7
Length of new rhizomes in cm.	15.7	13.1	11.1	1.3	0.0	0.0	2.2	1.6
No. new stems 45 days following replanting in fresh soil	109.0	30.0	19.2	0.0	0.0	0.0	16.9	12.0

* Pound per acre equivalents: .125% — 5; .25% — 10; .50% — 20; 1.00% — 40; 1.50% — 60.

In the second experiment maleic hydrazide was applied to the leaves in concentrations of .25, .50, and 1.00% and at several pound per acre rates (Table 5). Control groups were sprayed with water and with sodium trichloroacetate at a rate of 100 pounds per acre. Within ten days after the treatments were made, plants sprayed with sodium trichloroacetate were showing injury and the foliage gradually became white in appearance. By the end of the experimental period all of the original stems were killed, however the herbicidal effects were not sufficient to prevent the formation of numerous new shoots from buds at the base of the original break. Examination of the underground parts revealed an average of twelve new rhizomes produced by the ten original rhizome segments. The water controls formed an average of 41 new rhizomes for the ten segments. Compared with the water controls, significantly more of the original stems were killed and fewer new stems and rhizomes were formed by the material treated with sodium trichloroacetate.

Following foliage application of maleic hydrazide, the leaves became dark green in color and developed considerable anthocyanin pigment. Three to four weeks later, the tips of the leaves became brown and this condition continued to spread over the entire leaf surface. All of the maleic hydrazide treatments were effective in reducing the number of new stem breaks which appeared after treatment. The new stems, few of which exceeded 4 to 5 centimeters in length, may have started before translocation of the maleic hydrazide to the rhizomes. The lower portions of some of these new stems and leaves were still slightly green in color at the conclusion of the experiment and were not considered killed. It is probable that these would have died within a short period.

Seventy days after the herbicides were applied to the foliage, an examination of the underground parts in treatments where the kill of above ground parts was high showed that no new rhizomes had formed. However, where the kill was not complete, some of the original rhizome segments had formed new rhizomes. Five of the fourteen maleic hydrazie treatments had produced an average of one new rhizome by the ten segments originally planted. The remaining nine treatments possessed no new rhizomes. These difference are not significant and a high degree of significance was obtained between the maleic hydrazide treatments and both the sodium trichloroacetate treated groups and the control group. It is believed that these treatments may not have received a uniform coverage of maleic hydrazide since each was sprayed with a relatively low volume of solution per acre. The necessity for complete and uniform coverage with herbicidal materials is thus emphasized.

The material was replanted after an examination of the underground parts was completed. A large number of new breaks occured in the water control lot, however only a few breaks developed in the

Table 5

Effect of Foliage Application of Maleic Hydrazide on Quack Grass
Data Taken 70 days after Treatment and Based on Six Replicates,
Each Containing Ten-3 node rhizomes segments.

Pounds per Acre of Maleic Hydrazide	Percent increase in number of stems			Percent of total stems killed			Number of rhizomes formed by 10 segments		
	Percent Solution			Percent Solution			Percent Solution		
	.25	.50	1.00	.25	.50	1.00	.25	.50	1.00
5	133	107	—	90*	99*	—	1.0	0	—
10	114	110	104	100	94*	95*	0	1.0	1.0
15	110	120	124	100	98*	98*	0	0	1.0
20	—	112	101	—	100	100	—	0	0
25	—	103	114	—	100	94*	—	0	1.0
30	—	105	112	—	100	100	—	0	0
Na-TCA 100 #/A		271			23*			12	
Water Controls		368			0			41	

* All stems present at time of treatment killed.

lots treated with sodium trichloroacetate and with .25% maleic hydrazide. Individual replicates which were treated with .50 and 1.00% maleic hydrazide and which had formed new rhizomes, also produced a few new breaks, however, there was no relationship of new breaks to the strength solution nor to the rate of application.

Discussion

The results presented indicate that under the conditions of these experiments, maleic hydrazide is an effective herbicide for quack grass. Applications as a preemergence treatment to soil containing inactive rhizomes or to young plants as a foliage spray retarded or completely inhibited the formation and growth of stems and new rhizomes. When applied to the soil larger quantities of the chemical are necessary to effect equal control than when used as a foliage spray.

Maleic hydrazide applied to the foliage effectively inhibited tillering of shoots and the development of new shoots from buds located on the rhizomes. It also inhibited the formation of new rhizomes. Apparently the herbicide is translocated to the underground portions of the grass.

Under the conditions of these experiments, maleic hydrazide is more effective against quack grass than is sodium trichloroacetate. Although foliage treated with sodium trichloroacetate was killed more rapidly than foliage treated with maleic hydrazide plants treated with the trichloroacetate produced many new stems and a few rhizomes during the 70 days following treatment.

Application of 29 or more pounds per acre of maleic hydrazide to the soil not only completely prevented growth of the quack grass but also brought about injury and rotting of the rhizomes. When replanted in uncontaminated soil, rhizomes failed to develop either new stems or rhizomes. In contrast rhizomes located in soil treated with 100 pounds per acre of sodium trichloroacetate showed some new growth when replanted.

Soil treated with 29 pounds per acre of more maleic hydrazide retained toxic properties for at least 49 days after treatment. It is not known how long soil may be rendered unfit for replanting following such treatment.

Foliage application of .25% or less of maleic hydrazide although effectively killing the foliage is not sufficient to prevent new growth from the rhizomes. Thus it would appear that the more concentrated solutions, .50 and 1.00%, should be tried under field conditions.

Summary

Maleic hydrazide applied as a preemergence treatment to the soil or as a foliage spray to young plants is effective in killing or inhibiting continued growth of stems and rhizomes of quack grass.

Application to the soil of as little as 5.8 pounds per acre significantly reduced the number of stems and rhizomes which developed from segments of inactive rhizomes. At 29 pounds per acre there was a complete inhibition of growth. Soil treated with 29 or more pounds per acre of maleic hydrazide retained toxic properties 49 days after applications were made.

At 29 and 58 pounds per acre rates, .05% solution of maleic hydrazide were more effective than .1% solutions. A more uniform distribution of the larger volumes used in the .05% applications is believed to be responsible.

Foliage applications of .25% of maleic hydrazide at rates of 5 to 20 pounds per acre killed young foliage and significantly reduced the number of rhizomes which were produced. Application of .50 and 1.00% at rates of 5 to 30 pounds per acre not only killed the foliage but also prevented development of new rhizomes. When this material was replanted in uncontaminated soil new shoots developed are in those replicates which contained new rhizomes.

Compared with sodium trichloroacetate, soil application of 29 pounds per acre of maleic hydrazide was as effective as 100 pounds per acre of the sodium trichloroacetate. Foliage application of as little as 5 pounds per acre of .50% to 1.00% maleic hydrazide resulted in more effective control than 100 pounds per acre of sodium trichloroacetate.

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Results of Two Years Research, in Six Southeastern States, With Thirty-one Chemical Herbicides for Track Treatment of Railroads.

Jack P. Taylor

The comparatively recent development of numerous chemical herbicides, all with merit for particular weed control problems, and the desire to employ those rapidly developing herbicides for treating railway ballast sections, brought about the need for an extensive research program under actual track conditions. Since there was no reported research on weed killers for railway ballast treatment it was necessary to track test all chemical herbicides. This need for such research, prompted a cooperative program in 1949, between The R. H. Bogle Company of Alexandria, Virginia, The Department of Chemical Engineering of Virginia Polytechnic Institute, the Seaboard Air Line Railroad, and the Southern Railway System. This program was continued in 1950 by The R. H. Bogle Company and the Southern Railway.

Obviously, there is considerable difference between off-track and "on-track" testing, as, with a built up ballast section for the particular purpose of providing drainage, chemicals are more easily leached from the ballast and sub-ballast than would be expected when chemicals are applied on level ground. Chemicals suitable for track treatment must kill all types of vegetation, they must be extremely versatile since treating over a wide area (1000 miles, more or less) will involve all types of vegetation, weather conditions, different soil conditions, etc., and, above all, they must be economical. To include all factors which effect chemical herbicides and to evaluate these chemicals, for treating the ballast section of railroads in the Southeastern United States, it was necessary to test at several locations and all during the growing season.

To eliminate as many combinations as possible, fifty laboratory or greenhouse tests were made. The rate of application was double that which was to be used in the actual track tests. This would offer a good safety factor and thus those chemicals which gave poor results could be eliminated. It will be sufficient to state that twelve formulas showed good results in the greenhouse but under actual field conditions none of these gave good results, except sodium chlorate-calcium chloride which was a proven herbicide for railroads. The following list gives those chemicals and combinations which were tested in the laboratory.

1. Kerosene-water emulsion
2. Kerosene-2, 4-D acid-water emulsion
3. Kerosene-2, 4-D acid-sodium hydroxide-water emulsion
4. Kerosene-2, 4-D sodium salt-water emulsion
5. Kerosene-2, 4-D sodium salt-sodium hydroxide-water emulsion

6. Kerosene-Esteron 44-water emulsion
7. Kerosene-Esteron 245-water emulsion
8. Kerosene-Borax-water emulsion
9. Borax
10. Velsicol 750-water emulsion
11. Velsicol 751-water emulsion
12. Velsicol 760-water emulsion
13. Velsicol 761-water emulsion
14. Velsicol 750-2,4-D acid-water emulsion
15. Velsicol 751-2,4-D acid-water emulsion
16. Velsicol 760-2,4-D acid-water emulsion
17. Velsicol 761-2,4-D acid-water emulsion
18. Sodium acetate
19. Kerosene-sodium acetate-water emulsion
20. Sodium acetate-sodium hydroxide
21. Sodium chlorate-calcium chloride
22. Sodium chlorate-sodium hydroxide

Procedure for Track Tests:

The following procedure was used in making the track tests and determining results:

Locations:

1. Palmetto, Florida - Seaboard Air Line Railroad
2. Valdosta, Georgia - Southern Railway System
3. Marion Junction, Alabama - Southern Railway System
4. Chattanooga, Tennessee - Southern Railway System
5. Rock Hill, South Carolina - Southern Railway System
6. The Plains, Virginia - Southern Railway System

Application dates of the tests at each location were between April 11 and September 14, 1949, as shown below:

	Late Spring	Early Summer	Late Summer
Palmetto	4-13 to 4-19	6-20 to 6-22	8-15 to 8-18
Valdosta	4-25 to 4-28	6-27 to 6-30	8-19 to 8-24
Marion Junction	5-3 to 5-9	7-7 to 7-8	8-26
Chattanooga		7-12 to 7-15	8-29 to 8-30
Rock Hill	5-15 to 5-25	7-19 to 7-21	8-31 to 9-1
The Plains		8-4 to 8-5	9-14

The spray equipment was constructed on a small scale of regular application spray cars so it could be assembled, dismantled, and transported by truck between locations. A 167 gallon capacity tank was used. Spraying was accomplished with a 2" centrifugal pump which developed a pressure of 15 pounds per square foot. Nineteen equally-spaced nozzles were mounted so that even coverage was obtained on a 20-foot width. The equipment was mounted on a push car and propelled by a motor car so the operator could maintain a constant, predetermined speed of 4-1/2 - 5 mph when spraying.

Application of Test Formulations. All tests were made on 1/4-mile plots covering a 20-foot width. Before application color 35mm still and 16mm motion pictures were made and the type vegetation and percentage of each occuring in the plots were recorded. A soil sample of each plot was taken three feet from the ballast edge for later analysis.

Each formula was applied as a total solution of 100 gallons, except in the case of the aromatic oils. A total of 197 tests were made during late spring; 162 tests during early summer; and 95 tests during the late summer. Including the laboratory tests, a total of 88 formulations were investigated. During late spring 40 formulations were tested at each location. Those formulations showing negative results were eliminated and 28 formulations were applied during early summer. Again, formulas showing negative results in the early summer application were eliminated and only 18 formulas were applied during late summer.

The results of the first series of tests were not accepted as conclusive in eliminating a particular chemical or formula, with a few exceptions. Those formulas of lower concentration were repeated on the same plot of the first series, and those formulas of higher concentrations were applied on a new test plot. Then, if the results were still poor, those chemicals showing negative results were discontinued from further testing. The following chemicals and combinations were tested on track in specific concentrations:

1. Sodium chlorate-calcium chloride
2. Sodium trichloracetate
3. Sodium chlorate
4. Sodium pentachlorophenate
5. Sodium arsenite
6. Sodium hydroxide
7. Ammate (ammonium sulfamate)
8. Ammonium thiocyanate
9. Pentachlorophenol
10. Oil 214-A (marine diesel fuel)
11. Polybor
12. Esteron 245 (2,4,5-T isopropyl ester)
13. 2,4-D acid
14. 2,4-D sodium salt
15. Formula 40 (2,4-D alkanolamine)
16. Esteron 44 (2,4-D isopropyl ester)
17. Weedone 32 (2,4-D and 2,4,5-T butyl ester)
18. Sodium chlorate-sodium hydroxide
19. Sodium Trichloroacetate-Formula 40
20. Sodium trichloroacetate-Estern 245
21. Sodium pentachlorophenate-sodium trichloroacetate
22. Sodium arsenite-sodium pentachlorophenate

23. Sodium chlorate- sodium pentachlorophenate
24. Pentachlorophenol-sodium trichloroacetate
25. Oil 214-A-water emulsion
26. Kerosene-2, 4-D acid
27. Kerosene-2, 4-D sodium salt
28. Kerosene-Esteron 245
29. Kerosene-Esteron 44
30. Sodium chlorate-sodium trichloroacetate
31. Polybor-sodium chlorate

Results were determined by an observation one week and one month after application. The plots were inspected and the percentage "kill" was estimated for each type of vegetation. Percentage "kill", as used in this investigation, was defined as that percentage of the original vegetation which was dead or brown at the time of observation. Color 35 mm still and 16 mm motion pictures were taken of each plot at both the weekly and monthly observation.

Soil samples were analyzed for pH, organic matter content, and mechanical analysis by standard methods of analysis.

Weather data were obtained from United States weather maps, and reports from stations nearest the test locations, also during the application, data were recorded and used to check the accuracy of that obtained from the weather maps.

Discussion of Results:

The results show that the following chemicals or combinations have merit for railway ballast treatment in the southeast:

1. Sodium chlorate-calcium chloride
2. Sodium trichloroacetate-Formula 40 (2, 4-D alkanolamine)
3. Sodium chlorate-sodium trichloracetate
4. Sodium trichloroacetate-pentachlorophenol
5. Sodium arsenite-sodium pentachlorophenate
6. Sodium arsenite-oil 214-A-water emulsion
7. Oil 214-A
8. Polybor-sodium chlorate

Oil 214-A applied at the rate of 200 gallons per mile gave a high initial one-week kill, 80 to 100 per cent on the grasses and a lower kill, 50 to 70 per cent, on the weeds. In all cases, the vegetation showed a quick recovery and after one month the kill had reduced to 0 to 50 per cent, with an average of 10 to 20 per cent. It was concluded that oil was valuable as a herbicide to control growth - a chemical mower. Slightly better results (40 to 50 per cent after one month) were obtained when applied near the end of the growing season. The vegetation was not in an active growing condition and the results were longer lasting.

Polybor-Chlorate: Polybor was tested at a rate of 400 pounds per mile and gave extremely poor results. When combined with sodium chlorate, the results were very good - a kill of 80 to 100 per cent on weeds and honeysuckle. It was determined that the effectivness of the combination was due to the chlorate dosage and the polybor was valuable only to reduce the inherent fire hazard of the sodium chlorate. This combination offers no advantage over the sodium chlorate-calcium chloride weed killer and the cost is greater. On this basis the combination of polybor-sodium chlorate was eliminated.

Sodium Chlorate-Calcium Chloride. An excellent kill of Johnson grass and weeds was obtained when sodium chlorate weed killer (3 pounds chlorate per gallon) was applied at a rate of 150 gallons per mile. After one month the average kill was 90 to 100 per cent. On Bermuda grass the kill was not as good as on Johnson grass, 20 to 60 per cent. Repeat applications of 50 or 75 gallons per mile gave better results than one application of 100 or 150 gallons per mile.

Sodium Trichloroacetate-Formula 40 gave excellent results on Bermuda grass, 90 to 100 per cent kill after one month when applied at a rate of 200 pounds of sodium TCA and 2 gallons of Formula 40 per mile. The kill on Johnson grass, 60 to 70 per cent, was not as good as on Bermuda grass.

Sodium Arsenite-Oil 214-A was applied at a rate of 40 gallons of sodium arsenite (4 lb. As_2O_3 per gallon) and 100 gallons of Oil 214-A, as a water emulsion per mile. At all locations the kill on the perennial grasses was 50 to 70 per cent after one month. The initial kill (after one week) was 100 per cent for all types of vegetation. On weeds and broom sage a kill of 100 per cent was obtained. Similar results were obtained with sodium arsenite and sodium pentachlorophenate, 40 gallons of the former and 80 pounds of the latter.

Sodium Chlorate-Sodium Trichloroacetate. When it was noticed after the first series that sodium chlorate gave better results on Johnson grass and weeds and sodium trichloroacetate gave better results on Bermuda grass, the two chemicals were combined, this combination being used for the first time by any experimenter. Results after one month were excellent. The rate used was 200 pounds of sodium chlorate and 100 pounds of sodium trichloroacetate (60%) per mile. The percentage kill was 80 to 90 per cent on Johnson grass, 80 to 90 per cent on Bermuda grass, and 90 per cent on weeds.

Sodium Trichloroacetate-Pentachlorophenol. The rate used was 100 pounds of sodium TCA and 16 pounds of pentachlorophenol applied as an emulsion. The kill obtained was better for late summer application than late spring or early summer application. At Marion Junction, Alabama, the kill on Bermuda grass was 15 per cent in late spring, 70 per cent in early summer and 70 per cent in the late summer. This combination was applied on the same plot during each series at Marion Junction. The predominating type of vegetation was Johnson grass, and as stated previously, sodium TCA was not as effective on Johnson grass as on Bermuda grass. At Rock Hill, the kill was 30 and 100 per cent for late sp ring and late summer application. Weather conditions for Palmetto, Florida, and Valdosta, Georgia, were extremely dry and the results at these locations show a good kill on Bermuda grass at both late spring and early summer applications.

Effect of Type of Vegetation on the Efficiency of The Herbicides Showing Positive Results. It has been shown that various types of vegetation were effected more by one herbicide than another. Thus it becomes necessary to know the major type of vegetation before the most economical weed killer can be recommended. For ballast treatment in the southeastern United States, the combination of sodium chlorate and sodium trichloroacetate was found to give the best results on a mixed growth of Bermuda grass, Johnson grass, and weeds which are the most prevalent types of vegetation.

The effect of Soil Conditions on the Action of the Herbicides Showing Positive Results. The analysis of a soil sample of each test plot of the six locations showed that there were no major differences in type, pH, or organic matter content. The soil type varied from sand to sandy clay loam; sand at Palmetto and Valdosta, and Sandy clay loam at the other locations. The differen ce in pH were from 4.0 to 7.0; soil of lower pH was found at Rock Hill and Valdosta. Organic matter content ranged from 1.0 to 7.0 per cent; the lower content was found at Rock Hill and somewhat higher at Palmetto (3.0 per cent). No significant effect on the action of the herbicides could be determined from different soil conditions.

Conclusions:

From the analysis of the results of 50 chemical herbicides tested on the ballast section of branch and shortline railroads at Palmetto, Florida; Valdosta, Georgia; Marion, Junction, Alabama; Chattanooga, Tennessee; Rock Hill, South Carolina; and The Plains, Virginia, it was concluded that:

1. The following chemical herbicides had little value for track ballast treatment when applied at the rates indicated per mile, on a 20-foot width;

   a. Ammate (ammonium sulfamate) applied in quantities of 800 pounds or less.
   b. Ammonium thiocyanate, when applied in quantities of 200 pounds or less.
   c. Sodium chlorate, sodium hydroxide combination, applied in quantities of 220 and 100 pounds or less, respectively.
   d. Sodium trichloroacetate, applied alone in quantities of 200 pounds or less.

e. Sodium pentachlorophenate, applied in quantities of 200 pounds or less.
f. Sodium pentachlorophenate, sodium trichloroacetate combination applied in quantities of 100 and 50 pounds or less, respectively.
g. Sodium chlorate, sodium pentachlorophenate combination, when applied in quantities of 120 and 80 pounds or less, respectively.
h. Pentachlorophenol, when applied in quantities of 24 pounds or less.
i. Oil 214-A water emulsion, when oil was applied in quantities of 200 gallons or less.
j. Kerosene, fortified with 2,4-D acid, 2,4-D sodium salt, Esteron 44, Esteron 245, and Weedone 32, in quantities of 200 gallons or less of keresene; and 8.8 pounds, 4 gallons, 1 gallon, and 6 gallons or less of the 2,4-D types mentioned above, respectively.

k. Polybor, when applied in quantities of 400 pounds or less.

2. The following chemical herbicides showed promise for railway ballast treatment in the southeast.

a. Sodium chlorate-calcium chloride
b. Sodium trichloroacetate-Formula 40 (2,4-D Amine Salt)
c. Sodium trichloroacetate-pentachlorophenol
d. Sodium trichloroacetate-sodium chlorate
e. Sodium arsenite-sodium pentachloraphenate
f. Sodium arsenite-oil 214-A
g. Oil 214-A

3. The greatest factor affecting the action of the herbicides was the type of vegetation.

4. Sodium chlorate was more effective on Johnson grass than on Bermuda grass.

5. Sodium trichloroacetate was more effective on Bermuda grass than on Johnson grass.

6. Sodium arsenite in combination with sodium pentachlorophenate and in Oil 214-A was effective on weeds and broom sage and only partially effective on the perennial grasses.

7. Oil 214-A was valuable only to control vegetation or act as a "chemical mower" when applied in quantities of 200 gallons or less per mile.

8. Sodium chlorate (200 pounds), sodium trichloroacetate 60% (100 pounds) gave an average per centage kill one month after application of 80 to 90 per cent on Bermuda grass, Johnson grass, and weeds on each of 12 tests.

9. Sodium trichloroacetate, pentachlorophenol combination was not as effective as the other TCA combinations mentioned.

10. Two applications of 50 and 75 gallons respectively of sodium chlorate weed killer gave better results than one application of 100 and 150 gallons.

11. The determination of the effect of varying soil conditions on the action of the herbicides tested showed that no significant effect was evident from different soil conditions at the six test locations.

12. The determination of the effect of weather conditions on the action of the herbicides led to the following conclusions:

a. That in all cases better results were obtained when there was sufficient rainfall to produce active growth of the vegetation.
b. That the contact herbicides gave better results when the weather became dry after application.
c. That a hard, dashing rainfall of one or more inches was necessary to reduce the action of the herbicides materially.

13. The determination of the most effective time for application during the growing season led to the following conclusions:

a. That, with similar rainfall conditions, the results obtained with sodium chlorate weed killer and sodium trichloroacetate-Formula 40 were not effected by early or late season application.
b. That sodium trichloroacetate-pentachlorophenol, and Oil 214-A gave better results when applied during late summer (Aug. 15 to September 14, 1949).
c. That the sodium chlorate-sodium trichloroacetate combination gave the same results when applied between June 5 and September 4, 1949.

The analysis of the results of all formulations led to the following conclusion:

1. That the most economical chemical herbicide formulation for Johnson grass, Bermuda grass, and weeds, growing together, was sodium chlorate-sodium trichloroacetate, two pounds of the former to one pound (60%) of the latter.

Results of 1950 Tests:

The report above has dealt somewhat in detail with the results obtained in 1949. A similar program was conducted in 1950, although on a smaller scale. Two locations, Palmetto, Florida, and Chattanooga, Tennessee, were eliminated. Also, the early spring series of tests was not conducted.

Pre-application Inspection: To determine the accumulative benefit from one year to the next, an inspection of the plots at each location was made just prior to application this year. The greatest effect noticed was a change in the type of vegetation on plots where chemicals were used which had shown positive results. This inspection substantiated the conclusions determined in 1949. Generally it was determined that in the southeast where Johnson and Bermuda grass, and weeds constitute the major problem, the sodium chlorate-sodium trichloroacetate combination gave the best accumulative benefits. On plots where there was little grass, cheaper chemicals can be used.

Application and Results: In so far as possible the same chemical was applied on the plot used last year. Thus, the results of two years application could be determined. The rate of application of sodium chlorate-sodium trichloroacetate was varied, and the dilution factor was studied. Results of these studies indicate that for heavy Bermuda grass a slightly heavier dosage of TCA would be advisable. It was also found that poor results were obtained with the same dosage of chlorate-TCA when the quantity of solution applied was 200 gallons per mile. There was no difference in results at dilution rates of 400 and 600 gallons of solution per mile.

Tests were also conducted in which various types of 2, 4-D were incorporated with the chlorate-TCA combination. Results of these tests were very good. It was found that these additions were valuable for certain specialized problems; that is, where a particular type of vegetation is quite prevalent ;and one that chlorate does not kill. An example of this type is Trumpet Vine or Creeper.

All chemicals used last year that gave positive results were again tested this year. Similar results were obtained which bore out the conclusions reached in 1949.

SUMMARY:

After two years field testing of the majority of chemical herbicides it was determined definitely that for the best and most economical results, the proper chemical for the major type or types of vegetation must be used. Through a carefully planned program and changes in chemical, as dictated by the change in vegetation from year to year, economical results and a reduction in amount of growth will result. It is not inferred that sterilization of the ballast section can be expected with economic limits, nor is it inferred that it will be necessary to treat every year. However, quite satisfactory results can be expected.

The following are those chemical herbicides which are believed to be the most satisfactory for ballast treatment in the southeast:

1. Sodium chlorate-sodium trichloroacetate - for general control of annual and perennial grasses and weeds.

2. Sodium chlorate-calcium chloride - for annual and perennial weeds and for Johnson grass.

3. Sodium arsenite - for annual and perennial weeds where poisonous chemicals can be applied.

4. Sodium arsenite-sodium trichloroacetate - for annual and perennial weeds and grasses, except Johnson grass, where poisonous chemicals can be applied.

5. Sodium chlorate-sodium trichloroacetate with 2, 4-D additions - for, see 1 above, and for special types of vegetation.

PRACTICAL ASPECTS OF RAGWEED CONTROL PROGRAMS

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In January, 1947, the author was assigned the task of making a study of the hayfever situation in New Hampshire. After a perusal of the available literature, it was decided to use the pollen collecting techniques of the American Academy of Allergy. In addition to these airborne pollen counts, a reconnaissance survey was made of all highways, towns and cities in the State to determine the actual ragweed plant growths. These studies have been continued for four years. The number of pollen collecting stations have varied from twelve in 1947 to thirty-five in 1949. During the 1948 season the stations were maintained from March 15 to October 15, and all major hayfever pollens identified and counted. Counts of the airborne pollens and the mapping of ragweed growths are an integral part of any ragweed control program. These counts should also be correlated with topography, soil, vegetation and population. A vegetation type map, with the type and populations of the communities superimposed, will amost indicate the ragweed plant growth in itself.

During the 1947 season, there was no attempt to arouse local interest in a large scale control program. It was felt that the evidence of the pollen counts and ragweed growths were necessary before such an attempt was made.

An experimental control area was laid out along a main highway above the White Mountains, where ragweed growths were heavy. This plot was twelve miles long and in the heart of the recreation area. The New Hampshire Highway Department cooperated by spraying the roadsides with 2,4-D, using an orchard type spray rig. Total costs for this operation, including labor, equipment and chemical, was approximately $1.75 per mile, spraying both sides of the highway.

The Town of Lancaster, on the west end of this control plot, became interested in the project. They requested advice and were told to use 2,4-D sprayed from back-pack forest fire pumps. This Town controlled ragweed on all of its public areas by this method, and has continued this as a regular municipal project since then. The cost of this method of application is approximately $1.00 per mile, using regular town highway employees and equipment.

A 16 mm. motion picture camera was borrowed, color film bought, a script written, and a movie made showing the program. This film showed all phases of the work from pollen collection stations to methods of ragweed control. The film was edited to use with a prepared narration of the project. This has been a valuable aid in selling the control program.

In the spring of 1948 an attempt was made to inform all communities of the control program. Letters were prepared telling the full story and including the pollen index and ragweed growth classification for each community. The town fathers were requested to write the State Department of Health for free advice and particulars of a control program. A few towns made polite inquiries, but the only town actually spraying to control ragweed was Lancaster, which had done so the preceding year. Some progress was made, however, as the Highway Department Division Engineer in northern New Hampshire controlled about 75 miles of main highways in his division with the back-pack pump method and 2,4-D.

The author began talking to various civic groups during the 1949 season and succeeded in slightly increasing the number of communities participating. During this season, three other towns and one city entered the program on our advice. In addition to this, the Highway Engineer in the northern division controlled ragweed alongside all of his highways, and five other Division Engineers controlled parts of their highway systems. Total highway mileage controlled was about 350 miles.

Every community in the State was informed of the program in 1948 and 1949, urged to participate and offered free advice and supervision. The only places in which the spray control program was inaugurated was where the author talked, showed the film and spent some time in discussion with various groups. After three years of pollen study, mapping ragweed growths and sending literature to the authorities, there were only five communities participating in the program.

It was decided after an examination of the progress record that another method of selling the program was needed. This decision led to the author personally contacting the key people in each community in the northern half of New Hampshire, whether they were part of the government or an individual or group strongly influencing the local government. This personal contact method necessitated attending selectmen's meetings, long hours, talking to men at their work and a great deal of discussion and argument. This method of approach gave excellent results and almost more work than could be handled.

As a result of these various meetings, more than 100 of the 235 towns in the State agreed to the ragweed control program, approximately one-half of the land areas of the State. Some communities also wanted help in controlling poison ivy, which has been added to the ragweed control program. The New Hampshire Highway Department Division Engineers in this northern area were also contacted. They cooperated by 2,4-D spray control along all main highways where the towns were in the program.

The approach to these groups was made with actual cost figures in hand, practical methods of controlling ragweed worked out, and the proof that they could do the program themselves with available equipment. The facts of low cost, about $1.00 per mile in the north country, and the use of local labor and readily available equipment, have met almost universal approval.

Ragweed control can be done on a local level, with inexpensive equipment, cheaper than it can be done by the State. This is due to several facts, some of which are:

1. Local labor knows the area better and can better plan their work.
2. Equipment for small areas is available in each community.

3. Labor rate of pay is usually lower.
4. The State costs include meals, lodging, travel and administration.
5. Local labor is more interested and usually does more work per hour than State labor.

At least one man from each community was trained in the use and application of the 2,4-D. This was done at 21 training schools held throughout the northern part of the State. These training schools were so located that no individual had to travel more than 15 miles to attend. Even then it was necessary to visit at least one town in each training group which sent no representative. The author also spent at least one full day in seven of the larger communities training a crew of men and supervising their first day's spraying.

The method of application varied considerably from town to town. Most communities used forest fire back-pack pumps for application of the 2,4-D, standard fire equipment in each town. The 2,4-D was purchased locally, being the liquid 4 pound to the gallon alkano-amine formulation, with an oil spreader added, which was recommended. The chemical was mixed in a 50 gallon oil drum, placed on the tail-gate of a truck, and drawn through a faucet directly into the 5 gallon back-pack pump as needed. The usual crew was three men, one driving and two spraying along the roadsides. This was the cheapest method in New Hampshire, some town costs being less than $1.00 per mile.

The other common method of application was with the town forest fire pumper and even in two cities with the regular fire pumper. The use of this equipment necessitated much on-the-spot improvision for spray nozzles, and usually ended at a garage with drills and pipe scattered around. Workable nozzles were devised with little difficulty, and usually a great deal of pride, by each local group.

The City of Manchester, largest in New Hampshire, was the only place where standard spray rigs were used. These were two tree spraying units mounted in large trucks, which worked in excellent fashion. The regular tree spraying crew was turned over to the author for the job. The hardest thing to do with this crew was to restrain their enthusiasm so that they would not spray everything in sight with 2,4-D.

Costs per mile, including both sides of the highway, ran from $0.40 to $2.00, and averaged between $1.00 and $1.50 per mile. The average figure is the proper one to use, the lower in the north country. The author, when asked for an estimate for community spray programs, takes the total miles of highway in the town and puts a dollar sign in front of it. This estimate includes all roads and many have little or no ragweed growth.

The charge of $0.40 a mile is a community where the salaried fire department was used. The authorities said they were glad to put the firemen to work. The $2.00 per mile is the larger cities, with unionized labor and expensive equipment. For the average New Hampshire community, the cost per mile should not exceed $1.25 per mile of highway. This cost is based on total mileage in the community, and the density of ragweed growth on a state-wide basis, which is light compared to most other areas.

The most difficult part of starting a ragweed control program has been money for the purchase of chemicals. Equipment and labor for application have been easily obtained. When the local authorities have refused or been unable to finance the purchase of chemicals, the author has usually been able to find some civic group to supply funds for chemicals and the communities have been pleased to apply it.

Response for chemical money has been varied, and in some cases unexpected. Funds have been furnished by Women's Clubs, Men's Clubs, cabin owners, hotel owners, town health officers, regional recreational associations, and Chambers of Commerce. These groups have backed the program for one season and indications are that the programs will continue on a municipal basis, now that the method has been proven. In the City of Laconia, the Chamber of Commerce supplied funds in 1949 with a show-me attitude. They were so pleased with the program that the funds for chemicals were doubled in 1950, and are planned as a regular part of their annual budget. Here the City Engineer and fire department cooperate in the application.

Following are some of the results from the above methods of ragweed control. These are airborne pollen counts for a four year period, together with ratings of ragweed growths from the reconnaissance survey:

Town	Ragweed Pollen Grains/Sq.Cm. Slide Area				Ragweed Growth Classification				2,4-D Spray Control
	1947	1948	1949	1950	1947	1948	1949	1950	
Colebrook	4	22	17	0	L	L	L	L	1949-50
Laconia	8	298	55	12	H	H	M	L	1949-50
New London	0	48	188	16	L	M	H	L	1950
Concord	73	58	139	114	H	H	H	H	None
Nashua	38	700	813	641	H	H	H	H	None
Manchester	-	140	179	59	H	H	H	L	1950
Lancaster	-	-	32	-	M	L	L	L	1947-50
Bethlehem	-	-	58	-	L	L	L	L	1949-50

L = Light; M = Medium; H = Heavy (New Hampshire conditions).
Dash indicates station not maintained in that year.

From the foregoing table, it can be seen that the ragweed control methods being used in New Hampshire are getting results, even as the reconnaissance surveys indicate ragweed is increasing its range and density. Particular attention is invited to New London. During the 1947 survey, it was difficult to find ragweed plants in the town, and the author found no pollen on exposed slides. Ragweed growths were found in patches along the roadside during 1948 and the pollen count had jumped to a 48 total. The 1949 season revealed almost continuous ragweed growths along the roads and the pollen count had increased to 188 total. The ragweed spray control program was inaugurated in 1950, at a cost of about $1.00 a mile. The method of application was back-pack pumps with 2,4-D. Growths were well controlled and the slide count dropped to a 16 total. This is also demonstrated at Laconia, where the results of a two-year spray program drastically reduced the airborne pollen count.

The following conclusions may be drawn from the New Hampshire ragweed control program:

1. Local labor and available equipment can be used to control ragweed at an average cost of about $1.25 a mile.

2. It is not necessary to use expensive and complicated spraying machinery to get control.

3. Control programs are more economical on the local level and incline to be more efficient.

4. A Statewide program would get best results by supplying the chemical to communities and instructing them in its use.

5. This type of control program dramatically reduced the amounts of airborne ragweed pollen.

6. Best results in starting a program are obtained by getting into the field at a local level and contacting key people. These contacts should be supplied with practical facts and figures, not a mass of scientific facts.

SYRACUSE, NEW YORK, RAGWEED CONTROL PROGRAM

Information which has come to me indicates the objectives of most of the papers presented at this conference deal with efficiency of various methods of destruction of weeds. I have obtained no data from our experiences in the Syracuse Department of Health which will add anything to the facts you already have in this field. For the most part it seems to me you are primarily interested in the economic or commercial aspect of the control of weeds. This paper does not deal with this phase of the problem. Some of those present may ask why I bother to read this material if it has no bearing on the factors which may be of prime interest to most of you. I want to present this paper for two reasons. First of these is to bring out some of the public health aspects of eradication of weeds. Second is to illustrate ways and means of conducting such a program, although sufficient funds are not provided in the budget for such purposes.

The functions and duties of full-time health departments are divided into three main categories which are the collection and analysis of vital data; the investigation and control of diseases which affect the masses, and environmental sanitation. In the control of conditions pertaining to diseases which affect the masses we are interested in those conditions which influence the comfort and well-being of the individual as well as those which may actually cause death.

It is a well established fact that those of us who suffer from hay fever about thirty per cent will develop asthma eventually, and other complications may follow. The pollens from various sources cause hay fever. In the region in and about Syracuse about ninety per cent of the hay fever seems to be caused by the pollen from ragweed. Since no attempt had been made to eradicate ragweed in Syracuse prior to the summer of 1948, there were many well seeded areas throughout the city. There have been no surveys in this area which can give us any data as to the approximate number of hay fever sufferers there may be. However, by observation and from reports from physicians, clinics and hospitals, we were convinced there was a sufficient hay fever problem to make it practicable to conduct a ragweed eradication program.

One of the first steps was a survey of the city, which indicated that there were many vacant lots in which there was ragweed and other weeds which should be removed. It was also found that many streets, between the curb and the sidewalk, contained dense growth of ragweed. Many of these streets are in the downtown area. A check-up on the vacant lots indicated about thirteen thousand were owned by the city. In the alleys and back yards of private property were many areas in which ragweed flourished. Another interesting observation was made during the survey, and that was that rodent infestation in vacant lots was influenced by the growth of weeds. Uncut vacant lots also seem to become dumping places for rubbish and garbage, despite city ordinances prohibiting this. In public health practice it is highly advisable to develop programs which will produce results in as many fields as possible. The eradication of weeds tends to reduce the amount of pollen which causes hay fever and also removes nesting and breeding places for rodents.

The facts indicated to us that we would be operating upon a reasonably sound policy if we undertook to eradicate as many weeds as possible. We tried to interest various lay groups such as the garden clubs, schools, settlement house group and others in the eradication of weeds, especially ragweed, upon private property. The leaders cooperated and much publicity through press and radio was obtained, but we have never received much cooperation from private property owners.

Our Corporation Counsel informed us that we could mow privately owned vacant lots, if the owners did not do so after due notice. We were also informed that the fees for mowing could be collected from the property owners. However, this has never been done.

Having obtained much information pertaining to the problems and methods of eradication of weeds, particularly ragweed, we decided upon a program. This consisted of mowing those vacant lots which could not be sprayed to good advantage and spraying the areas between the sidewalk and the curbs with 2,4-D. Since we had very limited funds for this purpose we decided to start the program about July 15th and continue until about September 15th. We learned that ragweed which was mowed tended to throw out branches or shoots near the ground and develop pollen at a later date than the ragweed which had not been cut. We also learned that to pull ragweed out of the ground had a tendency to stir up the soil and increase the growth of ragweed in this area. Our first trials at spraying indicated that if we applied the 2, 4-D too early in the season the ragweed would send up another crop which would have pollen before the frost killed the plant. If we start about July 15th and plan a well-supervised spray program we can cover most of the heavily seeded areas by September 15th. It is true we get pollen from those plants sprayed during the middle of August and later, yet we are able to kill the plants and reduce the amount of reseeding. At first we tried to map out areas to be sprayed and give each driver of a spray team instructions for several days' spraying. We learned it is really advantageous to have a person assigned to supervise the work of the spray teams to keep them on the job and to be sure the areas are covered thoroughly.

In the Health Department budget were funds which could be used to purchase 2, 4 -D and one spray attachment for a jeep. There were other funds which we could use to employ one team and one tractor to mow vacant lots. However, we had no personnel except an inspector who could act as a supervisor (too many chiefs and not enough Indians!). Since it is the duty of the Public Works Department to mow the streets, we approached the Commissioner of that department with the idea of a loan of a jeep and a driver to help spray out 2, 4-D. The Commissioner of Public Works offered the loan of one man, so we soon had one spray team operating. The horse-drawn mower and tractor employed with funds from the Health Department cooperated with the Public Works Department in the program to mow vacant lots.

Wherein the equipment and personnel were not sufficient the first year to bring about the results we desired, the program did stimulate interest in weed eradication for hay fever control. In 1949 three jeeps were equipped with spray attachments and through the cooperation of the departments of Public Works, Parks and Health, we were able to expand the program. In 1950 it was very evident that ragweed had been reduced in several heavily seeded areas of the city. However, we have never been able to obtain the cooperation of individual property owners in the eradication program. In 1950 the Department of Public Works purchased six tractor mowers to add to those used the previous years, so the Health Department did not take part in the mowing of vacant lots. Our funds were used to set up and maintain five pollen counting stations around the city. These counters were placed upon high buildings on the outskirts of the city. The slides were changed daily, and once each week they were collected and read by an allergist who donated his time. These counts were made to indicate the directions from which pollen was reaching the city. There may never be an opportunity to obtain cooperation in the eradication of ragweed in the areas adjacent to Syracuse, but the pollen counts from various areas will help indicate how great the concentration may be within the city because of ragweed growing there.

In addition to the five pollen counters in areas adjacent to Syracuse, one counter was placed on the roof of an eight story building in the central part of the city and pollen counts were made daily. These pollen counts were published in both daily papers. In the morning paper the pollen count box appeared in the upper left corner of the front page.

The work we are doing in weed eradication in Syracuse will contribute nothing scientific in regard to the methods used. In our city all purchases are made through the Department of Contract and Purchase, therefore I do not know where the 2, 4-D was purchased. Instructions received with the material, plus trials in dilutions our men made, determined the concentration of 2, 4-D we used. A fifty-gallon tank was set up in the back of the jeep, the pump was attached, the men carried five gallons of concentrated 2, 4 - D and as the tank became empty they filled it with water at a hydrant and added the 2, 4 - D solution. Our program will supply nothing of value to those who are interested in the commercial aspects of weed control for crop improvement. However, I believe our weed eradication program does demonstrate a plan of aid by the Health Department and cooperating agencies to those who suffer from allergic reactions to pollens from weeds. Much of the work of health departments is for the prevention of mortality, or deaths. This program indicates a trend to bring the work of the health department into a broader field where the comfort and welfare of the individual is given more serious consideration. We know we can never eliminate hay fever in Syracuse because we realize pollens can be brought to us from distant places, but we also realize hay fever sufferer will be much more comfortable if the vacant lot next to his home does not contain a massive growth of ragweed. We are really trying to conduct environmental sanitation programs which will have the widest possible influence upon the health and life of our people.

C.A. Sargent, M.D.
Commissioner of Health
Syracuse, New York

RAGWEED ERADICATION IN PINE HILL (ULSTER CO.) NEW YORK, 1946-1950

By
David Funk
and
Bertram Loeb

GEOGRAPHICAL AND HISTORICAL BACKGROUND

Pine Hill is in the northwestern portion of Ulster County, New York, approximately 36 miles northwest of Kingston. It is primarily a summer resort although there is some dairy farming and a little corn and hay grown. It has a winter population of approximately 5,000.

Located in the heart of the Catskills, its elevation is 1600-2000 feet above sea level. Surrounding hills go up to 4500 feet and for a radius of 25 miles there is no level country. Prevailing winds are northwesterly; annual precipitation is somewhat higher than the neighboring Hudson valley and central New York lowlands. Most of the area is heavily forested.

These geographical factors lower the incidence of air-borne pollen coming from any distance. The pollen found in the area is primarily of local origin.

Although Pine Hill has been a summer resort for half a century, it was not too widely known as a hay fever resort area. The New York State Department of Health issued a map of low pollen areas in 1938 which showed northwestern Ulster County as the second best region in the state, but most summer guests were attracted to Pine Hill by other qualities. Nevertheless for many years a small percentage of vacationers were hay fever sufferers.

In 1945, the senior author of this paper, who operates the Funcrest, one of the largest hotels in Pine Hill, became convinced of the possibility of developing Pine Hill into a hay fever resort. Having favorable geographical factors, a ragweed eradication campaign seemed to offer the possibility of greatly reducing the pollen count.

In order to accomplish this, several factors had to be considered.

a) The incidence and characteristics of ragweed
b) Methods of control
c) Enlistment of community support
d) The economics of ragweed control.

This paper will describe how each of these problems has been met.

I.

THE INCIDENCE AND CHARACTERISTICS OF RAGWEED

The species found in Pine Hill is the common ragweed. No giant ragweed exists in the area. Because of the heavy forests on the hillsides, the ragweed grows primarily in the hollows where man has improved the land. In order of importance, ragweed is found on the following types of land:

a) Roadsides
b) Areas of recent construction, excavations and clearings
c) Farms and gardens
d) Railroad rights of way and stations
e) Lawns, golf courses and meadows
f) Abandoned property

The ragweed seems to follow the law of gravity. As the snow on the hillsides and embankments melts in the springtime, it carries along the ragweed seed, depositing them in the hollows. The ragweed plants begin to grow in May but practical eradication cannot begin until June 15 at the earliest. Pollination starts during the first week of August and continues through to the middle of September. This gives a period of two months that can be used for ragweed control. Eradication should be planned to be completed before the beginning of pollination.

The favorable distribution of ragweed in the Pine Hill area simplifies the problem considerably. Instead of necessitating the coverage of an area of 25 square miles, the work can be narrowed down to a dozen roads and the land 150 yards on both sides plus farms, hotel grounds and three miles of railroad right of way.

One other factor of importance is the characteristic of ragweed seed to remain dormant for years in the ground until suitable conditions for growth occur. Isolated areas with no contamination show sudden growths after the ground is disturbed by a bull-dozer, plow or cultivator. This necessitates constant rechecking and an intimate knowledge of the community to insure thorough eradication.

An idea of the special problems involved because of this characteristic can be had from the experience with ragweed eradication in the area of the Belle Ayre Mountain ski lift. This recent State-financed construction necessitated the timbering of a sizable area and the building of nearly a mile of road.

Because the lift construction cut through a heavily-forested area at a fairly high altitude, not much ragweed growth was expected last summer. This expectation was borne out forthe actual area of the lift. However the shoulders along the mile of access road, also carved out of the forest, showed fairly heavy ragweed growth.

Investigation revealed that tons of gravel had been brought in from an adjoining community to provide a road base. The spring thaw had washed the ragweed seed out of this gravel and deposited them along the shoulders and below embankments. During October of this year more gravel was brought in to continue the road-building. There is strong reason to believe that next summer this road will again show contamination.

METHODS OF CONTROL

During the past five years several different techniques have been tried out. The method now being used is a combination of them, based on this experience. They are:

a) Pulling up the weed by hand
b) Spraying with 2,4-D
c) Mowing with hand sickle, scythe or lawn mower

The method used depends upon location, density of growth and stage of plant development.

From June until the beginning of August, the first two methods are primarily used. Briefly the procedure is the following:

A crew of two is assigned a given road and the land on both sides of it. The crew is equipped with a low-gallonage sprayer, consisting of a pump-up garden sprayer of three gallon capacity with an eight-foot boom. At the end of the boom are three nozzles 18" apart. Each nozzle has built into it a 200 mesh strainer which causes a uniform spray pattern of evenly divided droplets. The hood serves to prevent the fog-like spray from drifting.

The sprayer is filled with a solution consisting of two ounces of a 40 per cent amine salt of 2,4-D in a gallon of water.

The crew pulls up by hand all scattered plants; where the growth is heavy, it is sprayed with 2,4-D.

Approximately one week later the same crew rechecks the ground covered to note the effect of the work, to respray where needed and to pull any weeds that may have been missed.

Where the growth is particularly heavy, the entire property is systematically covered with the 2,4-D spray.

This method of control is quite effective. Generally one spraying is sufficient to destroy the plant or to inhibit its development to the point of preventing pollination.

Approximately a month after the original eradication, a final check is made.

Because of the land covered it is difficult to estimate the acreage that can be controlled with a given amount of 2,4-D. Three gallons of spray will probably effectively cover 300 square yards or a mile of average roadside with shoulders two to six feet wide.

A special problem arises when the ragweed is growing on farms or gardens. Because of the destructive effect of 2,4-D on most broadleafed plants, ragweed on this type of land must be pulled by hand. It has been necessary on several occasions to reimburse farmers for a portion of their crops when hand-pulling was impractical and 2,4-D spray had to be used destroying part of the crop.

On extensive areas such as golf fairways, mowing at regular intervals has been found to be a fairly effective method of control.

Where eradication could not be completed before pollination, it was found practicable to mow the ragweed with sickle, scythe or lawn mower. When ragweed has been mowed it is advisable to burn it so that the pollen that remains on the plant is destroyed.

Rechecking the areas previously weeded is an absolute essential. A rainstorm the same afternoon will dilute or wash away the 2,4-D spray to the degree that it is ineffective. Roadsides that have been previously covered very often exhibit a new growth when a recheck is made two weeks later. It is advisable when rechecking an area to traverse it in a different direction than that previously covered so that any plants that may have been hidden from view are revealed.

After eradication is completed a notice is mailed to all property owners asking them to report any ragweed that may have been overlooked. This provides a final check.

The New York State Department of Health maintains pollen survey stations in Pine Hill and the neighboring communities in Big Indian and Fleischmanns.

The results of the ragweed elimination program can be seen from the following table:

Table I

Ragweed Pollen Counts in Pine Hill, 1946-1949.

(Courtesy of New York State Department of Health)

	1946	1947	1948	1949
No. of days with counts of 25 or more	4	3	3	1
Maximum daily count	140	146	58	28
Total seasonal count	340	396	378	236
Pollen Index	6	6	5	2

COMMUNITY COOPERATION IN RAGWEED CONTROL.

Of major importance to any ragweed eradication program is the degree of public support and assistance that can be engendered. Ragweed eradication is not a single season project; in order to obtain any degree of success a continuing program over a period of years is necessary.

At the outset of the program in 1946 community support was extremely limited. There were even some feeling of resentment, based upon the misguided notion that this was merely the private project of one individual, sponsored for his own private interest. It took several years of patient explanation and concrete results to dissipate this feeling completely.

During the summer of 1946, David Funk initiated the campaign by paying as much as $1.50 a bushel for all pulled ragweed. This method had the primary purpose of stimulating public interest in ragweed eradication. Even this limited program resulted in a heightened interest on the part of the business men of the community, acting through the Pine Hill Chamber of Commerce. From that year onward a voluntary fund has financed the program. In 1948 the Town Board of Shandaken Township, of which Pine Hill is part, made a small appropriation to help finance the program. This has been continued in the following years.

The growth of community support was due to the fact that hay-fever sufferers began to come to Pine Hill in increasing numbers. The business men in the community realized that ragweed eradication was not only good public health activity, but was also good public relations and a profitable investment in terms of increased business.

A special committee of the Chamber of Commerce, with David Funk as chairman and consisting of hotel owners, merchants and farmers, publicized the campaign. They helped to educate the community to the health hazards of ragweed, taught residents how to recognize it and methods of destroying it.

During the past four years, Pine Hill hotels have made a special point in their advertising of the benefits to hay-fever sufferers. Publicity material prepared by the Chamber of Commerce has gone out to thousands of sufferers, as well as in answer to casual inquiries of vacationers. The result has been an increased percentage of hay-fever sufferers who have come to the area each year during the late summer.

The actual process of ragweed eradication has also resulted in much word-of-mouth publicity. Since every populated section of the community is covered, it is common knowledge that ragweed elimination is under way. Vacationers who may not be hayfever sufferers have told friends who are allergic to the pollen about Pine Hill's efforts.

Good community relations have been further strengthened by the great care exercised to avoid any property damage in the process of ragweed eradication. This was insured the cooperation of local farmers whose lands are heavily contaminated and whose non-cooperation could jeopardize the entire program.

It became evident almost immediately that the success of the program in Pine Hill depended to a great degree upon expanding operations into the neighboring communities of Big Indian, Oliverea and Fleischmanns. A program of education for the business men in these communities was therefore embarked upon. The Big-Indian - Oliverea and Fleischmanns Boards of Trade were induced to hold several discussions on ragweed eradication at which the senior author of this paper explained the Pine Hill program.

In 1948 Big Indian-Oliverea and in 1949 Fleischmanns started their own ragweed eradication campaigns. The three communities have coordinated their programs and divided responsibilities for specific boundary areas. Pine Hill, for example, has extended its campaign into the village of Highmount which lies between PineHill and Fleischmanns. In addition there is an interchange of equipment as well as an exchange of ideas and techniques. The results in terms of the three communities can be seen from the following table:

Table II
Pollen Index for three Communities 1944-1949
(Courtesy of New York State Department of Health)

Community	1944	1946	1947	1948	1949
Pine Hill	a	6	6	5	2
Big Indian	23	a	a	a	3
Fleischmanns	a	a	a	a	7

a) No pollen count made. No count made in all three communities during 1945.

THE ECONOMICS OF RAGWEED ERADICATION

Three factors should be considered under this heading:

a) Cost of equipment
b) Cost of spray
c) Personnel

It is possible to plan an ambitious program costing many thousands of dollars but for a small community this is neither necessary nor feasible. The actual equipment that will meet the needs is the following:

a) Low-gallonage sprayer or orchard-type sprayee
b) Hand sickles, Scythes and power mower with sickle bar

Because there is a great deal of roadside contamination, it is planned in 1951 to mount an orchard-type sprayer on a truck, using a motor driven pump. This equipment is not practical for a small community because of the financial outlay, but is valuable where several communities throughout a county cooperate in a ragweed eradication program.

The cost of spray is determined by the territory to be covered.

The most important item is personnel. It is not sufficient alone for the director of the program to be well-organized, thorough and well-versed in the characteristics of ragweed. All the crew members must also be conscientious, alert and able to do a thorough job without immediate supervision.

Continuity of personnel is also important. The crew members need a detailed knowledge of the areas of contamination, based on the accumulated experience of past years. Otherwise much time will be wasted in fruitless searching, leading inevitably to duplication of effort and unnecessary work.

A crew of two who are familiar with the community, the characteristics of ragweed and methods of eradication can do a many-fold more effective job than an untrained crew of four.

The actual cost of ragweed eradication for the five years of the progam is shown in the following table:

Table III

ANNUAL EXPENDITURES ON RAGWEED ELIMINATION

	1946	1947	1948	1949	1950	TOTAL
Pine Hill	$200	$500	$600	$600	$600	$2500
Big Indian	0	0	100	200	300	600
Fleischmanns	0	0	0	600	600	1200
Total	$200	$500	$700	$1400	$1500	$4300

In addition, David Funk spent approximately $500 privately for ragweed bounty, equipment, and the use of Funcrest Hotel facilities and personnel.

The $5000 spent on ragweed elimination during the past five years represents the gross income from 50 summer guests staying for a two week period and spending approximately $50 a week apiece. When this is weighed against the approximately one thousand additional summer vacationers who have come to the area during the past four summers because of its low pollen count, it is easy to see that ragweed elimination has brought an extremely sizable economic benefit to the communities.

CONCLUSIONS

A. It is possible to eradicate ragweed substantially throughout a small community if consistent effort over several years is maintained.

B. In Pine Hill, where a combination of favorable geographic and meteorological factors exists a continued and thorough ragweed eradication program has reduced the pllen count throughout the area to the practically pollen-free level.

C. Community support and financial assistance are a necessity for a successful program. It would not be possible for a small community such as Pine Hill to carry through a ragweed eradication program for public health considerations alone. Tangible proof of economic advantages is needed before the required funds and assistance are forthcoming.

D. The elimination program must be based upon a thorough knowledge of the community and its areas of contamination; a continuing study of the local characteristics of ragweed; and a well-organized campaign using capable trained personnel and adequate equipment.

E. Methods of eradication must be varied according to the density of growth, location, time of year and economic considerations.

F. 2,4-D, used in a low-gallonage sprayer in the previously-mentioned concentration, is an effective controlling agent.

TABLE IV.

COMPARATIVE POLLEN INDEXES FOR VARIOUS COMMUNITIES IN THE CATSKILL AND ADIRONDACK AREAS (1946-1949)
(Courtesy New York State Department of Health)

Location	County	1946	1947	1948	1949
Keene Valley	Essex	-	1	1	3
Long Lake	Hamilton	3	1	4	8
Pine Hill	Ulster	6	6	5	2
Big Moose	Herkimer	3	5	4	9
Tannersville	Greene	6	4	5	-
Severance	Essex	-	4	4	10
Wanakena	St. Law.	6	4	5	11
Indian Lake	Hamilton	-	6	3	12
Lake Placid	Essex	6	-	7	13
Speculator	Hamilton	15	2	5	13
Tupper Lake	Franklin	-	7	5	15
McKeever	Herkimer	-	1	11	19
Zena	Ulster	-	9	14	11
Windham	Greene	30	0	38	30

RAGWEED AND POISON IVY CONTROL PROGRAM ON A CONTRACT BASIS
CITY OF SUMMIT NEW JERSEY

The following brief paper is submitted for discussion, and I trust the discussion will bear fruit.

A brief description of the community is that it is almost completely a suburban community town of 18,000 people. There are a few small industries, and two larger plants in the confines of the City, the CIBA Pharmaceutical Products, Inc. and the Celanese Corporation of America. The Bell Telephone Laboratory is on the southwest border in a neighboring municipality. There are sixty-five miles of paved roadways bordered by homes surrounded by lawns and gardens. The land is approximately sixty per cent developed. Two years ago it was estimated that there were approximately 100-125 acres of ragweed scattered along the borders of the roadways in outlying districts, most of the weeds within 100-200 feet of the roadway borders, Poison ivy could be found in the brush and woodland in many undeveloped spots.

The population are predominately well educated, prosperous citizens and decidedly health-conscious. The health officer has for years recognized ragweed and poison ivy as a public health nuisance and has carried on a steady fight for the eradication of these noxious weeds by enforcement of the so-called standard ordinance covering the elimination of these weeds. The fight was a continuously-uphill-battle with only fair enforcement accomplished and a repetition of the fight year after year.

The best reminder of the responsibility of the property owner for these noxious weeds was to enclose in the annual spring tax bill a circular quoting the law. This circular has kept the problem before the property owner but has failed to do more than just keep the subject alive. Large property owners have cooperated to a degree but the small property owner continues to plead inability to secure labor to destroy it. The City has cut ragweed on City-owned property.

Having gone through this tiresome program for a number of years with indifferent success, it occurred to me that, since all would benefit, this project could properly be considered a city-wide project, regardless of where the weeds or poison ivy grew.

Armed with this argument the idea was sold to the Board of Health and to the Common Council. A sum of $1,500 was appropriated for the purpose and a specification set up on which bids were asked. A number of concerns operating in the area were canvassed for bids, but only one bid was received. It was learned that, while all had machinery to spray, only one was so equipped that the equipment could be used for the destructive chemicals.

It must be noted that equipment used for the spraying of 2-4-D should not be used to spray shrubs and trees unless it is very thoroughly washed out after using the 2-4-D spray.

After receiving my bid of $1,500 and awarding the contract, work on the following specification was started:

"Your bid for the following work is solicited, the object being to destroy the poison ivy and ragweed (giant and dwarf) in the City of Summit, N. J.
"This bid must be in the office of the health officer by May 22, *** - nine o'clock.
"The following are the requirements for the work:
Furnish all labor and materials for the destruction of all ragweed (giant and dwarf) and poison ivy on property in the City of Summit:
The material to be used should consist of a solution of 2-4-D used in the strength of one pound to the acre.
The content of the material should be 53% of the ester and amine salt of 2,4-D equivalent to 3¼ lbs. of 2,4-D acid per gallon.
The area to be sprayed is approximately 125 acres, consisting of roadways and gutters adjacent to the City and County roads and such other vacant property adjacent to those roads that have growth of ragweed or poison ivy. The roadways consist of 75 miles.
It will be required to apply three sprayings as follows:
FIRST:- Apply killing spray to poison ivy by June 15, ***:
SECOND- Not later than July 15, **** spray all poison ivy, ragweed (giant and dwarf) and noxious weeds:
THIRD:- Not later than August 10, ****, spray all poison ivy and ragweed.
It is understood that a designated representative of the Board of Health shall have the right to inspect and approve the mixture of materials used and the nature, extent and quality of the work performed.
It is necessary to have complete coverage of insurance against damage done to property, trees, shrubs, plants and flowers in the performance of this work, in that at all times the Board of Health of Summit, N. J. is protected from damage suit, either to property or to person.
The work must be one in a businesslike manner continuing to a conclusion, weather permitting. The work should not be done except on clear dry days.
A map is on display in the Board of Health offices showing Board of Education property, City-owned property, City and County roads on which, or along which ragweed and poison ivy must be eradicated according to specifications."

My report on the work was as follows:

The first spraying was started June 10th and the operation was completed in ten days. The weather was ideal for this type of spraying. All property owned by the City having ragweed or poison ivy was sprayed thoroughly, including roadway borders.

The mileage was about one hundred, - the acreage of ragweed and poison ivy could only be estimated roughly. The spray solution was put on several times stronger than specified. Some seventy pounds of 2,4-D were used. This insured a quicker and more permanent kill.

A complete inspection of the work was made June 30th to determine results of the first spraying.

A second spraying of ragweed and poison ivy was completed in August and, while it would be impossible to state that all the ragweed and poison ivy have been destroyed, inspections revealed that there is a very marked improvement. Many owners of private properties have cooperated, encouraged by the previous Ragweed and Poison Ivy Eradication Program.

Contacts on numerous occasions with the County authorities elicited assurance that the County would cut rageed on County roads. Due to lack of manpower on the county roads, the ragweed was not cut. Many attempts were made to have it sprayed, but the powers to be elected to cut, if possible. We should eradicate ragweed and poison ivy along county roads in Summit. When the County fails to eradicate ragweed on county roads, our whole project fails.

County Roads:

Morris Avenue	Mountain Avenue	Ashland Road
Passaic Avenue	Summit Avenue	Baltusrol Road
Broad Street	River Road	

Work started June 17th and continued through June 18th; June 20th; June 21st; June 22nd; June 23rd; -- August 15th, August 16th; August 17th and August 19th.

A Total of 7,100 gallons of 2,4-D solution.

RESULTS: <u>POISON IVY</u> - Good control with complete kill, except in those areas where the vines had grown to as much as 20 feet in height, or where clumps were situated where protective grasses, immune to the chemical, were abundant. Here defoliation occurred.

<u>RAGWEED</u>: During the first application what ragweed sprayed was killed. During the second application in August, ragweed ranging from one foot in height to six feet was observed and sprayed. A subsequent check within 24 hours, after the first application, showed definite effects.

SUMMARY - Two thorough applications are necessary annually - one in the early part of June, primarily for poison ivy control and the second, in the second week of August, when the larger part of the ragweed development may be discerned from other growths and before pollination occurs.

Areas covered were all city-owned property, including schools, playgrounds, etc. and all the city-owned street lines, where, in many cases, application was made well beyond the 12 foot limit.

If this program is to be continued in 1950 effectively, it will be necessary to have on hand an appropriation of $2,000. This will enable a more thorough coverage and a more liberal use of material, especially where poison ivy is concerned. In the more difficult areas the ground soaking is of utmost importance, if a total kill is required.

The destruction of poison ivy, the most annoying of the two, was very successful. The ragweed eradication was excellent, but unless all surrounding communities have the same program, we shall have some effects of ragweed pollen in the air. For several years an attempt has been made to have the State develop pollen-count stations to locate heavy pollination spots. The State of New Jersey has not gotten around to this but I am sure that they will. I have spent considerable time with the State Department of Health representative, Dr. Marie A. Sena in this connection. In the meantime, until such an arrangement can be enforced, much time must be spent in selling the idea of eradication of ragweed and poison ivy to all surrounding areas; Millburn has taken on the program; Maplewood is far advanced in the work. Much correspondence and time have been spent in missionary work with New Providence, Chatham and Springfield. After the second year of our intensive program, as outlined, it is felt that a minimum, possibly $500 will not only keep the weeds in control, but eventually eradicate them.

The Board at one of its regular meetings, felt that an increase in the 1949 allotment of $1,500 to $2,000 for 1950 was necessary to carry on a program for 1950 and should be included in the 1950 budget.

My experience was good and in 1950 I was allotted $2,000; the process was repeated and the report was as follows:

Work was started on 6/16/50 and continued through 6/17;6/19; 6/20;6/21;6/22/6/23;6/25; - 7/15; 7/17; - 8/9; 8/10; 8/11; 8/12; 8/14.

A total of 13,650 gallons of 2,-4-D solution representing a total of 230 pounds of actual 2-4-D was used.

RESULTS: POISON IVY - Good control with complete kill, except in those areas where protective grasses and other vegetation, plus intense shade prevented ground soaking and maximum efficiency of the chemical. Here, it may be observed that up to a fifty per cent kill was effected and the balance of the vines are either in a dying condition or the foliage inactivated by severe chlorosis and necrosis.

Subsequent seasonal application will serve to completely eliminate resistance.

RAGWEED:- During the first application much giant ragweed was observed, sprayed and killed, especially along the County roads. Subsequent applications were applied to both giant and dwarf varieties with complete control.

A direct example of the effectiveness of this treatment may be observed on Baltusrol Road, going in the direction of the City line at Springfield. No ragweed will be observed along this route except where spraying ceased at the line, where at this point onward ragweed of all sizes flourishes in abundance.

The reaction of the public, generally, was good, some were even grateful. It is surprising, however, how many people cannot identify ragweed or poison ivy. Many are completely ignorant that these plants exist either on or near their property. One person would not allow any spraying along her property line, said she would take care of the matter herself. One complaint was received because of damage to several small seedling Dogwood trees planted near the curb amidst poison ivy growth. This was settled.

Careful spraying was done in the direct vicinity of vegetable gardens, and, in some cases, the weeds were cut by hand in order to avoid possible damage.

Large tree-climbing poison ivy, especially along the County roads had to be cut by hand in such a manner as not to injure the trees.

It appears that most of the ragweed and poison ivy infestation was along roadsides and worked over lands which had their natural meadow grasses destroyed. Gross weeds and plants (including ragweed and poison ivy) immediately move in these areas to cover the raw, lean soil, and, soon these plants dominate giving little chance for the more desirable growth to take hold.

The Board's program tends to reverse this condition and soon these areas will be covered by unobjectionable growths. A good example of this process is the City-owned lot at the corners of Morris and Mountain Avenues. Originally, this land was heavily ladened with both poison ivy and ragweed. Now it is completely clear except for a few anemic wisps of poison ivy which have no significance and are rapidly being overgrown by seedling Maples and non-objectionable weeds.

There are some deep rough grounds which have been subjected to the dumping of acid soil and refuse. These are ideal breeding grounds for the pests. The only way these may be cleared is by an expanded program, or the pinpointing of the properties and enforcement of the ordinance.

In conclusion, we have done all that is possible to make our program a success. This year we had in addition the long unbroken lines of the County roads. These were in such a deplorable condition that much additional time and material were required, as you may see from the record. This was compensated for somewhat by speedier application made possible by altering the special 2-4-D applicator machine.

It is believed that, in another year, our ragweed incidence will be minor. This year the ragweed was not so noticeable and more attention was given to poison ivy. By 1951 more attention can be given to this noxious growth, poison ivy.

The program was marked with success primarily because the contractor doing the spraying was civic-minded, conscientious and well-schooled in the growth and characteristics of ragweed and poison ivy.

Due to the fact that the City is practically surrounded with large areas of ragweed no attempt has been made to plate-count pollen to determine the benefits. After the idea is sold to bordering municipalities and the weeds are destroyed over a wide area, the counts will be of some use.

A check made among medical men revealed that ragweed allergy cases were milder or scarce.

October 16, 1950

Henry P. Dengler, M. D.
Health Officer

RAGWEED CONTROL PROGRAMS OF NEW JERSEY

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District Health Officer
Division of Environmental Sanitation
N. J. State Department of Health

Over the years it was known that some municipalities of the State of New Jersey conducted or participated in some form of weed control programs. Only a few details of such local programs were known.

In order to learn more specifically how many municipalities in New Jersey conduct or participate in ragweed and poison ivy control programs, the New Jersey State Department of Health included the following question concerning such programs in the 1949 annual report of local boards of health. "15. Did the local health department conduct or participate in a program for the eradication of ragweed or poison ivy in 1949? If so, describe the program briefly." These annual reports are required to be submitted by law to the State Department of Health.

A study of the replies to this question in the annual reports revealed that seventy boards of health of the 569 municipalities in New Jersey did some type of weed, ragweed or poison ivy control work or cooperated with other agencies. In many of the replies a brief description was given of the programs carried out by local boards of health. Other replies indicated that weed control work was conducted in the municipality by agencies other than local boards of health. A variety of programs conducted or type of weed control work done in the municipalities are as follows:

1. All weeds on empty lots are cut from March to October by the Street Department.

2. All vacant borough owned property sprayed with 2,4-D with facilities and personnel of Department of Public Works. Many privately owned properties are treated similarly with excellent results. A real concerted follow-up program is thought too expensive. No funds are granted for a good program.

3. The local boards asked the Road Department to cooperate by cutting ragweed and poison ivy in the borough.

4. The borough has an ordinance to provide for the removal of ragweed, poison ivy, etc.

5. When a complaint involving ragweed was reported to the board of health, the Department of Public Works was notified by the board to take care of this complaint. The Public Works Department sprayed all lots during summer months.

6. Voluntary community program under the supervision of the board of health.

7. Elimination of poison ivy a continual procedure in the interstate park in areas of heavy use. Control is obtained with sprays and dry chemical application.

8. Police Departments asked property owners to cut down ragweed. Appeals are made in a local newspaper to cut down ragweed.

9. The board influenced the Mayor and Council to have the Road Department men spray and cut throughout the borough.

10. The borough cuts the weeds from the sidewalks.

11. By the borough cutting brush, ragweed and poison ivy from the highways and sidewalks. Many private owners have had their vacant lots bulldozed and leveled.

12. Mosquito spraying contractor employed by the board also sprayed ragweed as complaints were received.

13. Highway Department acted with board in spraying lots and along walks for weed and poison ivy control.

14. On receipt of written complaint the Parks & Public Safety Division would spray ragweed and poison ivy growth. Intensive educational program is fostered by circulars and other media.

15. The borough enforces the local ordinance.

16. Program conducted by Shade Tree Commission and local board. Controlled allergy causing weeds by spraying with 2,4-D. Expenditure of $1400 produced good results in that ragweed and poison ivy has been nearly eradicated. Complaints from hay fever sufferers have been greatly reduced.

17. Cutting weeds and burning.

18. Notices served after inspection for weed removal. A two man team available for mowing lots on agreement with property owner.

19. On the basis of a written complaint the Parks and Public Property Division eradicates the nuisance. Four hundred ninety-nine boards of health either failed to answer the question or stated that no program of weed control was conducted.

Replies to the annual reports indicated that municipalities in 16 of the 21 counties of New Jersey conducted or participated in weed control programs. Table #1 shows the counties and the number of municipalities which conducted or participated in some form of weed control programs.

Table 1. New Jersey Counties and the Number of Municipalities Conducting or Participating in Ragweed and Poison Ivy Control Programs.

County	No. of Municipalities
Atlantic	1
Bergen	17
Burlington	0
Camden	1
Cape May	3
Cumberland	1
Gloucester	1
Hudson	4
Hunterdon	0
Essex	16
Mercer	2
Middlesex	5
Monmouth	1
Morris	3
Ocean	2
Passaic	2
Somerset	1
Union	10
Warren	0
Salem	0
Sussex	0

The seventy municipalities which indicated in the annual reports that some form of ragweed or poison ivy control work was conducted were circularized by a more detailed questionnaire late in September of this year. This questionnaire probed for information about the 1949 and 1950 weed control programs so that a comparison could be made between the programs conducted.

Forty local boards of health from 13 counties returned the questionnaires and thirty boards failed to comply with our request. One board gave some information over the telephone rather than complete the questionnaire. Many of the forms were only partially completed. Table #2 shows the counties and the number of municipalities which returned questionnaires containing information on their weed control programs.

Table 2. New Jersey Counties and the number of municipalities returning questionnaires on ragweed and poison ivy control programs.

County	No. of municipalities returning questionnaires
Atlantic	1
Bergen	9
Cape May	1
Cumberland	1
Hudson	3

County	No. of municipalities returning questionnaires
Essex	11
Mercer	1
Middlesex	3
Monmouth	1
Morris	2
Passaic	1
Somerset	1
Union	6

The following remarks are made to summarize the ragweed and poison ivy control programs which were conducted or participated in by local boards of health based on the questionnaire.

1. Weed control programs were conducted in 29 municipalities in 1949 and 29 municipalities in 1950.

2. Ragweed was controlled on private premises in 25 municipalities and on public property in 28 municipalities during 1949 and 1950.

3. Eleven municipalities reported that 226 acres of ragweed were mowed in 1949 and 227 acres in 1950.

4. Seventeen municipalities reported that 1604 acres of ragweed were sprayed with herbicides in 1949. Eighteen municipalities reported spraying herbicides on 1495.3 acres in 1950.

5. Four municipalities reported cutting 5.5 acres of poison ivy during 1949 while three municipalities cut 4.5 acres of poison ivy in 1950. Eleven municipalities sprayed 239 acres containing poison ivy during 1949 and twelve municipalities sprayed 237 acres containing poison ivy during 1950.

6. Eighteen municipalities sprayed a total of 55,463 gallons of herbicide at a cost of $2,971.18 for the 1949 program. In 1950 nineteen municipalities used 64,904 gallons of herbicide. Twenty municipalities reported an expenditure of $2,876.32 for herbicides during the 1950 program.

7. Ten municipalities stated they mixed their own herbicide solutions in 1949 and nine mixed herbicide solutions in 1950. The 2,4-D herbicide was used by practically all municipalities for spraying ragweed and poison ivy. A few municipalities reported the use of ammate in part of their programs.

8. Ten municipalities reported using only hand sprayers during the 1949 season and eight municipalities used only hand sprayers during the 1950 season.

Power sprayers were used by 15 municipalities during 1949 and 18 municipalities during 1950.

Six municipalities used both hand and power spraying equipment during 1949 and eight municipalities reported using both types during 1950.

A variety of types of power sprayers were used. Some municipalities constructed their own type of power spraying equipment with handy men employed by the various boards or other departments. The other types of power sprayers listed included Farquahar, Bean, Engine Parts Co., Hardie, Spartan, Walsh, Field Force trailer, and Lawrence Aero Mist. The capacities ranged from 8 1/2 gallons to 300 gallons. Pressures applied ranged from 30 pounds to 400 pounds.

Eleven municipalities reported the total cost of spraying equipment to be $6,878.76.

9. A total cost of the program for 17 municipalities was reported to be $13 798,88 for 1949 and 19 municipalities reported a total cost of $12,976.97 for 1950.

10. Only five local boards reported conducting ragweed and poison ivy control programs without cooperating with other departments or agencies. Other boards reported cooperating with departments of public works, parks, roads, sewer, shade tree commissions, mosquito extermination commissions and the engineering branches of local government.

11. Two local boards reported that their ragweed and poison ivy control programs were conducted on a contract basis with private contractor equipped with adequate spraying equipment.

12. Two municipalities reported the use of official pollen collecting devices during 1949 and 1950. According to information available from other sources there are actually four Durham pollen collecting chambers in official use in four separate municipalities in northern New Jersey. These are located in Maplewood, East Orange, Verona and New Brunswick. Teaneck reported that a local physician operated such a device for the past two years for his own information.

Table 3. List of municipalities having hand or power sprayers for herbicides and the population protected according to the 1950 census.

County	Sprayers for Herbicide: Power	Sprayers for Herbicide: Hand	Population
Atlantic County			133,000
Ventnor City	X	X	7,905*
Bergen County			538,000
Edgewater Boro		X	4,028*
Englewood	X		18,966*
Fairview		X	8,770*
Hackensack	X	X	29,207
Hasbrouck Heights		X	6,716*
North Arlington	X		9,904*
Teaneck	X		25,275*
		TOTAL	102,866

Note: * 1940 census

County	Sprayers for Herbicide Power	Hand	Population
Cape May County			37,000
Sea Isle City		X	773*
Hudson County			647,000
Jersey City	X		301,000
Kearny	X	X	39,828
TOTAL			340,828
Essex County			904,000
East Orange	X	X	78,000
Irvington	X	X	59,000
Maplewood	X	X	24,855
Newark	X		439,000
Nutley	X		26,746
Orange	X		35,817*
West Orange		X	28,624
TOTAL			691,942
Middlesex County			265,000
Highland Park		X	9,002*
Monmouth County			225,000
Sea Girt	X		599*
Morris County			165,000
Chatham	X		4,888*
Madison		X	7,944*
TOTAL			12,832
Passaic County			338,000
Passaic	X	X	58,000
Union County			399,000
Hillside		X	20,997
Summit	X	X	17,890
Union	X		37,989
TOTAL			76,876

Note: * 1940 census

Total population living in communities that are protected by power and hand spraying for the control of weeds according to the reports received is 1,265,583. The 1950 census indicated that there are 4,832,000 people living in New Jersey.

From this table #3 it is revealed that only about one fourth of the population of the State is protected in some degree by ragweed and poison ivy control programs. Most of this work is concentrated in the northeastern section of the State. The municipalities of Bergen County protect about one fifth of the population while Essex County protects a little more than two thirds of its population. Hudson County protects one half of its population.

We know that ragweed grows profusely on some neglected vacant land which may be disturbed by some local action as digging by children at play, building operations, road construction and grading, digging drainage ditches, etc.

Recent accumulation of dirt, ashes, refuse or garbage on open dumps or on vacant lots or land in urban or other areas where domesticated animals or wildlife burrows or disturbs the surface and subsurface of the ground is also productive of growths of an abundant amount of both giant and dwarf ragweed. Tin cans, old tree branches, wood or other debris, including broken down property line fences, old chicken coops, etc., where domestic rodents harbor, breed and maintain their home ranges in urban or rural areas, present ideal conditions for the propagation of weeds detrimental to public health, such as giant and dwarf ragweed as well as poison ivy.

These insanitary conditions in urban areas permitted by local boards of health or health departments begets more nuisances. Like begets like. One nuisance fosters another nuisance. We have been talking and preaching about insanitary conditions for a long time - too long.

This negative approach must be changed to one of positive basic sanitation. Good housekeeping can be maintained everywhere. Cleanliness must be stressed. A clean lot, a clean premises, a clean home, a clean business establishment, etc. must be emphasized again and again. This is a must for all, including public health officials.

Another important, but complex problem, is the control of weeds detrimental to public health in the agricultural area of this State. Much can be done in this field to aid and assist the farmer in producing crops free of weeds detrimental to public health by further research and economic development by the Federal and State Government agencies as well as by private industry. A great amount of this work has been done, more research is needed not only from an economic but also from a public health aspect. Agricultural Experiment Stations all over the country have done heroic work and private industry contributed to solve this problem by conducting intensive experiments in field and crop sanitation. A challenge presents itself to all concerned to produce a motive which will be economically feasible to sell to the farmer to produce crops more economically without contributing to or permitting a public health nuisance to exist.

<u>Ragweed in Agricultural Crops</u>

In a two day survey of agricultural area consisting of parts of Mercer and Middlesex County during the middle of September of this year an attempt was made to learn something about the density and growth of ragweed infesting cultivated crops, grain and other lands.

Approximately sixty-four acres of small type sweet corn about four and one half feet tall in five separate fields were examined for ragweed growth and thirty-seven acres showed a light dwarf ragweed growth, twenty-seven acres showed a heavy dwarf ragweed growth. It was noticed that this dwarf ragweed was distributed throughout the entire field with a heavy growth of dwarf ragweed around the perimeter of the corn fields.

The taller sweet corn and field corn generally showed a heavy growth of dwarf ragweed around the perimeter of the field but very little, if any, in the center of each field. Of the approximately eighty-eight acres of field corn seen in five separate fields, thirty acres showed a light dwarf ragweed growth, eighteen a medium dwarf ragweed growth and forty acres a heavy dwarf ragweed growth around the perimeters of each field.

A small fenced in chicken yard of approximately one acre showed a medium dwarf ragweed growth within the fenced in area and a light giant ragweed growth alongside of the wire fencing surrounding this field.

Grain fields, hay fields of clover, timothy and other grasses, pastures and fallow field consisting of about 630 acres showed that 280 acres showed a light dwarf ragweed growth, 30 acres showed a medium dwarf ragweed growth and 320 acres showed a heavy dwarf ragweed growth.

Of the twenty-one fields of soybeans having a total of approximately 761 acres, 260 acres showed a light dwarf ragweed infestation, 320 acres medium infestation and 181 acres of heavy dwarf ragweed infestation.

Eight tomato fields consisting of approximately 400 acres showed that 320 acres had a light dwarf ragweed infestation, 60 acres of medium infestation and 80 acres of heavy dwarf ragweed infestation.

Eight undisturbed potato fields were seen in this survey having approximately 328 acres. Thirty-eight acres showed a light infestation of dwarf ragweed, 100 acres showed a medium infestation and 190 acres showed a heavy dwarf ragweed infestation. Many potato fields which were still in the process of growing were free of ragweed and other weed.

A peach orchard of about 40 acres showed a heavy dwarf ragweed infestation while across the road a twenty acre apple orchard was kept in a clean condition showing no ragweed growth.

One wood lot of about 10 acres showed a light growth of giant ragweed and very little dwarf ragweed.

A radio and transatlantic telephone station consisting of about 800 acres more or less showed a heavy goldenrod growth among the short woody growths but very little ragweed.

In order to show the extent of agricultural crops grown in the general area where the survey was made, total acreage of the various crops grown in Mercer, Middlesex and Monmouth Counties was obtained from the Production Marketing Administration at New Brunswick and from the Bureau of Agricultural Economics, U. S. Department of Agriculture of Trenton. The following table #4 shows the estimated acreage from the data available of potatoes, sweet corn, field corn, grain crops (wheat and oats), soybeans and tomatoes grown during the years of 1948, 1949 and 1950.

Table 4. Estimated acreage of the following crops grown in Mercer, Middlesex and Monmouth County.

Potatoes

County	1949	1950
Mercer	9800	8258
Middlesex	9900	7877
Monmouth	13900	12059

	Sweet Corn	Field Corn
County	1948	1948
Mercer	500	9150
Middlesex	1100	7150
Monmouth	2600	13900

Grain Crops

County	Oats 1948	Wheat 1949
Mercer	2600	14500
Middlesex	800	10600
Monmouth	900	16500

Soybeans

County	1948
Mercer	3500
Middlesex	1100
Monmouth	2700

Tomatoes

County	1948
Mercer	1050
Middlesex	1250
Monmouth	2900

The challenge presented in controlling weeds detrimental to public health on private and public premises in urban and rural areas as well as on the farm is one which the public health officials and agricultural officials must work together to protect the public health, welfare and comfort of the citizens of this State.

Typed
11-17-50

A CONTINUOUS RECORDING PARTICLE SAMPLER

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A continuous recording volumetric particle sampler has been needed for some time in the field of public health, particularly in connection with the greatly expanded investigations of the last few years in the quantitation of ragweed pollen and its relation to pollenosis.

Various pollen collection devices previously have been available and have been used to good advantage in nationwide surveys (1), but most of these instruments have had disadvantages making them undesirable for detailed studies of pollen concentrations over small areas. The Standard Pollen Counting Station of the American Academy of Allergy, proposed by Durham (2), has the very considerable advantage of being simple, inexpensive, and devoid of moving parts. Its widespread use has given a gross picture of the variation in the concentration of pollen in the air overlying the forty-eight States and has provided an indication of the pollen present at any one point over a twenty-four hour period; but Wiley and Tarzwell (3), and Michael (4) have shown that the results given by this instrument are not consistently related to the volumetric count but vary widely with the wind velocity, rainfall, and other climatic factors. While, therefore, the device is well suited to the detection of large differences in pollen concentration, the variability of the measurements obtained make it unsuitable for investigations requiring the more exact quantitation of pollen in unit volumes of air over relatively small geographical areas.

These same disadvantages are inherent in any gravimetric device and resort has therefore been made by investigators to volumetric devices such as the Luckiesh, Holladay, Taylor Electrostatic Bacterial Air Sampler (3), and the Greenburg-Smith Impinger (4). These and similar devices, while showing a direct relationship between pollen concentration and air volume, have disadvantages, including the requirement of frequent human attendance and difficulty in the preparation of the specimen for examination. Hawes, Small and Miller (5) described a device which impinged airborne particles directly onto the surface of a moving microscope slide coated with petrolatum. This device had the advantages of ease of specimen preparation and enumeration as well as a direct particle number-air volume relationship, but inasmuch as the slide was limited to three inches in length, the instrument required rather frequent attendance.

Hazard and Drinker (6) described a continuous recorder for atmospheric dust in 1934, and in 1949 Lang (7) made suggestions for a continuous recording

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1/ From Technical Development Services, Savannah, Ga.

pollen sampler. Following these suggestions, the sampler described in the present paper has been designed, fabricated, and tested by the Technical Development Services of the Communicable Disease Center. The principle around which the sampler is designed involves the impingement of a given volume of air on the adhesive side of moving transparent cellulose tape, the passage of the tape with the adhered particles through a suitable staining bath, and the covering of the treated surface with a facing piece of tape.

The present models of the device have been built into a rectangular housing 9-1/4" x 11-7/8" x 13", one side of which opens on hinges to permit access to the mechanism. When closed the edges of the door are effectively sealed by a rubber gasket. A commercially available centrifugal blower rated at 50 cfm (free orifice) and powered by a small 110-volt alternating current motor is used to pump the air through the housing.

Movement of the tape is accomplished by the use of a 110-volt synchronous motor which, through a gear train, drives the take-up shaft at a speed of approximately one-half inch per hour or about twelve inches per day.

Several brands of adhesive tape are readily available on the market. A clear and transparent tape, 3/4" wide in twleve foot rolls, is used. The tape, as shown in figure 1, is passed from the feed roll under the air impinger tube, over the guide plate, through the staining bath and over guide rollers, where it meets and is pressed against the second tape, and thence to the take-up pulley.

The impinger tube has an inside diameter of 0.18 inch. Both ends are turned at forty-five degrees, to the surface, to form sharp edges. The tube may be raised or lowered as required, but optimum results are obtained where there is a clearance of approximately 1/16 inch between the end of the tube and the tape. With the blower specified and with necessary holes (4 holes 7/32" diameter and 1 hole 1/2" diameter) in the case for ventilation of the two motors, air is drawn through the impinger tube at the rate of 2.8 cfm with a velocity of 265 feet per second.

The intake orifice of the impinger tube is protected from rain by an inverted cap 1-3/8" in diameter. A circular piece of 16-gauge copper screen in the cap prevents the entrance of insects.

Over a period of several days operation the diameter of the take-up pulley increases as the tape piles up, thus increasing in turn the linear tape speed. To facilitate the relation of points on the tape to time, any one of several marking devices may be used. In one, the tapes, just after they meet, pass between two rollers, one stationary with a narrow slot in its circumference, the other revolving at any desired slow speed and carrying at one point on its circumference a short needle. The revolving shaft is normally driven by a one-revolution per hour electric clock motor and the roller diameter is such that the circumference speed is the same as the linear tape speed. At each hourly revolution of the roller the tape is marked by a tiny perforation visible to the eye and readily detectable under the microscope. As the distance from the perforation to the center of the impinger tube is fixed, the exact point on the tape related to any moment of time may be easily determined by measurement from the needle mark.

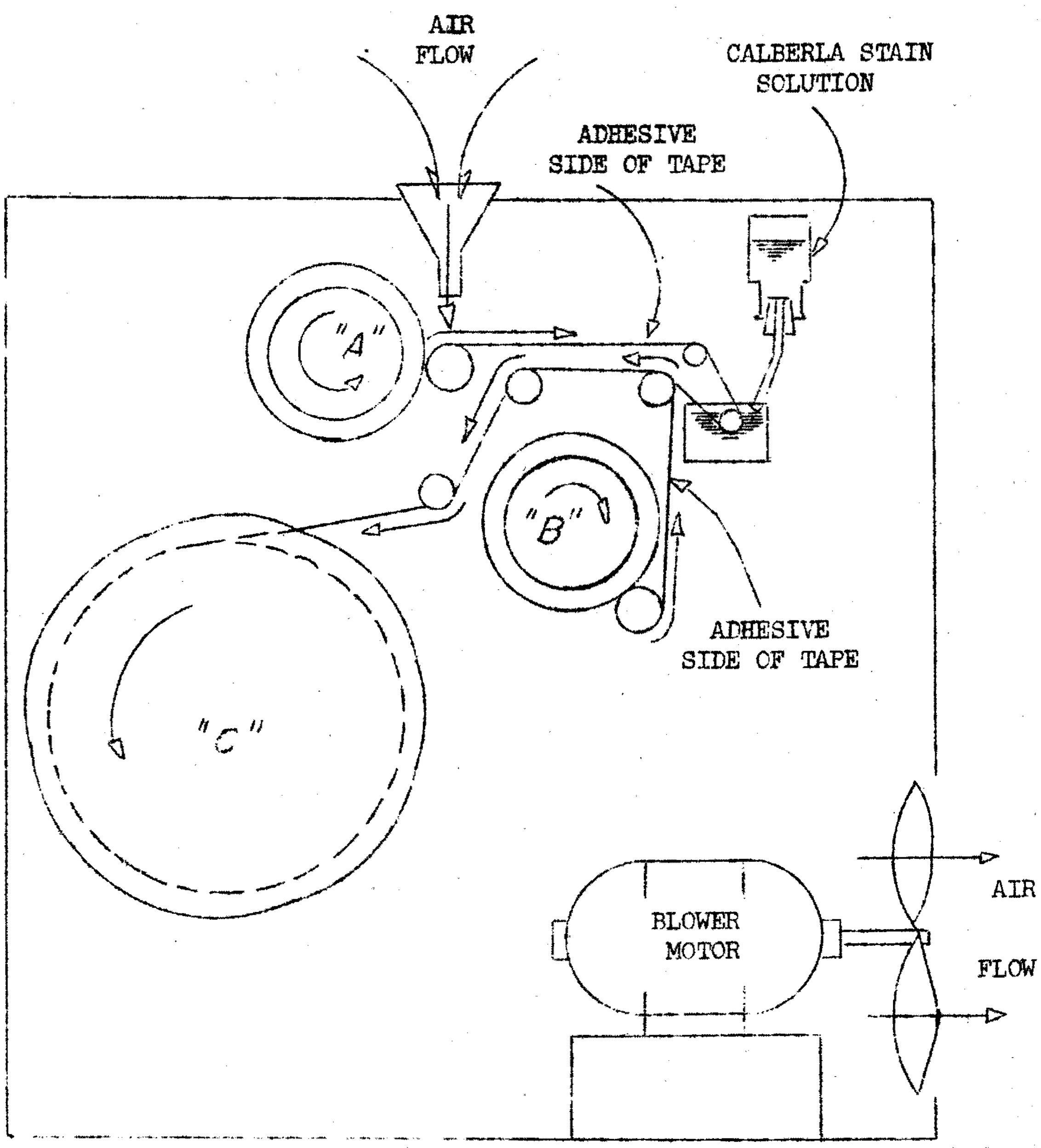


FIGURE 1

SCHEMATIC DIAGRAM

OF A CONTINUOUS RECORDING POLLEN SAMPLER

Another arrangement marks the collector tape by means of a solenoid operated needle located directly under the center of the impinger tube. The solenoid is actuated by means of an external timing device preset for any desired time interval, or by a manually operated push button at the will of the observer.

From these marks, lines are drawn across the tape with India ink and a ruling pen at intervals of 15, 30, 60, or more minutes as desired. A section of the tape is clamped to and stretched over a simple rectangular aluminum frame slightly wider and about the length of a standard microscope slide. This frame is placed in the mechanical stage of a microscope and the section of tape examined just as would be a glass slide.

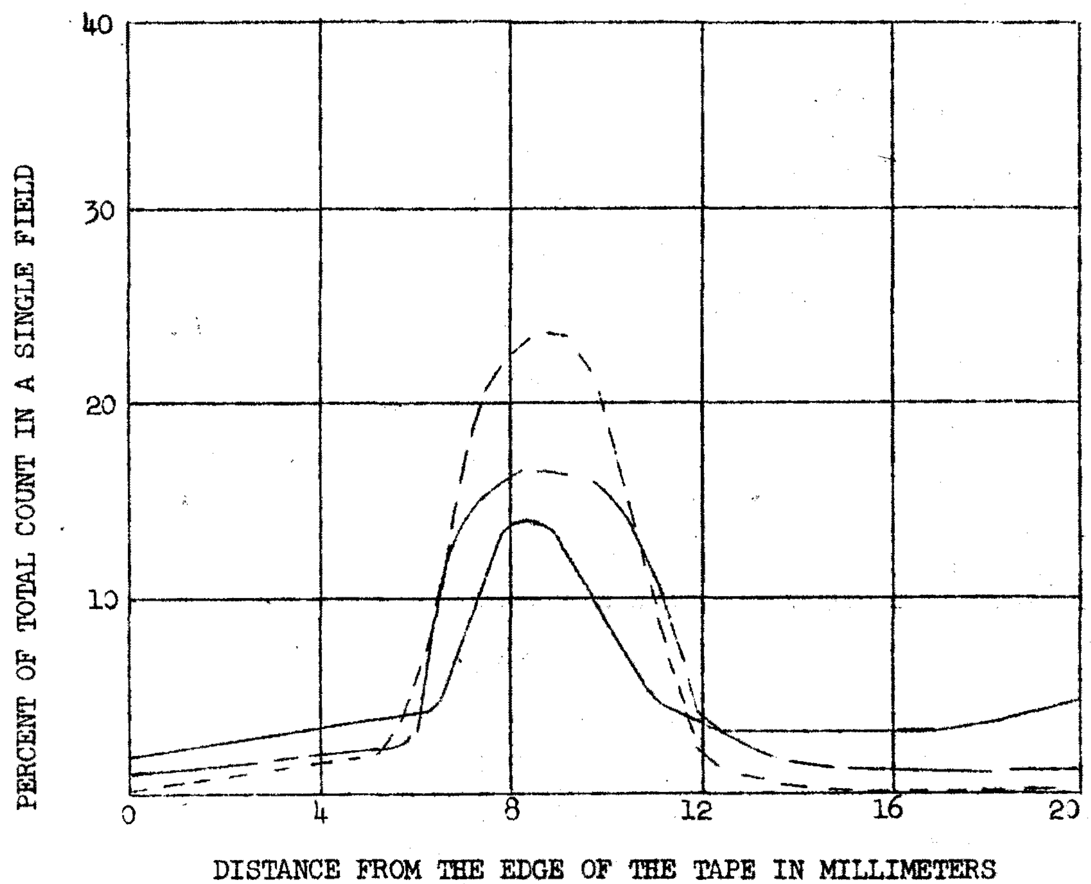
In originally checking the operation of the sampler, counts were made over the entire area of the tape for each hour of operation, that is, counting was done over the area 1/2" x 3/4". This procedure is necessary when an absolute count per unit of air is required. However, relative counts may be obtained with a great saving of time and effort by making one lateral pass between time marks at the center of the tape. The accuracy of this procedure is attested to by the concentration of the impinged particles in the center of the tape as shown in figure 2.

Preliminary tests have been made to determine the efficiency of this instrument by introducing a cloud of pollen into the air around the inlet and examining the exhausted air by passing it through a modified Greenburg-Smith apparatus as used by Michael (4). In the tests conducted, very few pollen grains were found to pass through the instrument with the tape in place. Verification of this fact was obtained by using petrolatum-coated slides distributed about the interior of the housing during tests in which the ventilation holes were closed. No method was devised to evaluate the other possible source of error, that of pollen loss by impingement within the inverted cap over the inlet tube. Losses here, however, reasonably may be considered to be small as the air velocity within the inverted cap area is low, some eight or nine feet per second. While no specific data on efficiency was obtainable by these methods, relative pollen counts of the slides under the two conditions plus the concentration of the pollen on the center of the tape permits the conclusion that the efficiency of the instrument is high.

A number of uses for the instrument, some involving modification, have suggested themselves. Where continuous recording is not essential and a condensed time scale will suffice for the projected operation, the instrument is equipped with automatic timing devices arranged to operate the blower, over a specific period of time, thus drawing a given volume of air through the inlet tube. The air and its contained particulate matter is impinged at a stationary point on the tape. The tape then is automatically transported to the next point an inch or two down the tape between the operating cycles of the blower. Thus, a sample can be taken once, twice, twelve, twenty-four or any other number of times a day. By concentrating the sample at one point on the tape the labor of examining and counting the particles is considerably reduced, and a sampler set up at a remote location can operate unattended for long periods of time.

Due to the portability of the instrument, it can be placed in a moving vehicle, such as an automobile or aircraft, for time-space survey purposes.

FIGURE 2



DISTRIBUTION OF PARTICLES IN THREE
PASSES ACROSS THE WIDTH OF THE TAPE

One unit used in this manner was modified by removing the exhaust blower and substituting for the 110-volt alternating current tape drive motor a 12-volt direct current motor driven by dry cells. The entire unit was mounted in the rear cockpit of a PT-17 airplane. The cap over the inlet tube was replaced with a periscope-like tube 1-13/16" in diameter which extended up and over the cowling into the slip stream of the plane, thus creating a positive pressure in the enclosed inlet tube. The large diameter tube was used in order to minimize particle impingement on the walls of the small-diameter bends which would have been necessary had the inlet tube itself been extended. To assist in the movement of air through the instrument the motor ventilation holes were closed and an outlet connected through a flexible tube to a double throat venturi mounted on a wing strut. The positive pressure on the inlet plus the negative pressure on the outlet moved air through the instrument at the rate of 9.8 cfm at an indicated air speed of 80 mph and at an elevation of 4,000 feet. Under these conditions the air speed in the impinger tube was computed to be 925 feet per second. These values were calculated from velocity data obtained by inserting the probe of a thermal anemometer into the exhaust line. In view of the relatively large volume of air, and to permit better time-space correlation of the tape with the terrain traversed in the plane's flight, the tape speed was increased to 1/4" per minute. The instrument thus modified and installed is being used to determine variations in pollen concentration over varying terrain and at different elevations.

Other units have been under field test during the past ragweed pollen season and some are currently being tested for their usefulness in surveying the concentration and migration of the spores of Histoplasma capsulatum and Coccidioides immitis which are the causitive agents of histoplasmosis and coccidioidomycosis, respectively. It is to be hoped that the use of existing or future models of this instrument may facilitate our accumulation of knowledge concerning the migration of these and certain other air-borne pathogens.

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PHYSIOLOGICAL EFFECTS OF CERTAIN WEEDICIDES on RHUS TOXICODENDRON L.

Introductory Remarks

Eradication of Rhus toxicodendron L. at Boy Scout Camps presents a twofold problem. First, large camping demonstrations are held early in the Spring when the leaves are starting to emerge; therefore, it is necessary to use a contact weedicide for rapid control to prevent contagion. Second, since the areas to be treated are extensive, it is necessary to use a weedicide that will permanently eliminate the plant with one or, at most, two applications to keep the operation economical.

Inquiries to manufacturers of weedicides revealed that general results could be predicted, but that they varied greatly with concentration, method of application, and types of chemical, and also the ecology of the plants.

To ascertain more definite knowledge of control methods in the New York-New Jersey area, a series of field applications and observations were made.

Field Methods of Application

The same property areas of Rhus toxicodendron L. were sprayed with either a mixture of 24D-245T or sodium pentachlorophenate.(1) In areas of concentrated growth as on stone wall, tree stumps and ground masses, a hydraulic spray at 50 p.s.i. was used. Effort was made to cover both the upper and lower surface of the leaves. In large fields, a mist was applied by a truck-mounted blower moving through the fields on parallel courses. Such fogging must be done when wind velocities are very low to prevent spread of the spray to surrounding vegetation.

Observations

Each day, after the spray had been applied, a leaf, stem section, and root section were microscopically examined.

Within one hour after 24D-245T had been applied, the guard cells on the lower surface of the leaf became distended causing the stomata to remain open. Changes in temperature and atmospheric humidity failed to cause a change in this condition. A possible explanation for this abnormal condition may be that the chemical causes an unbalance in the acidity of the fluid in the cells. Since the other cells in the epidermal layer do not contain chloroplasts as do the guard cells, the higher p.h. would result in a digestion of starch to sugar in the guard cells only. Therefore, the cell sap concentration would increase in the guard cells resulting in a transfer of water to the guard cells with resultant increased turgor pressure and distention. Because of this abnormal condition the stomata, in fact, become aborted and function as hydathodes.

Three to four days after the application, it was observed that the root hairs would enlarge and then split. This may be caused by the excessive transpiration which exerts an increased pull on the fluid column within the plant which is transmitted to the root cylinder. The removal of fluid from these cells again results in an increased cell sap concentration. The differential in concentration brings about a rapid osmotic transfer into the root hair cells, resulting in excessive turgor pressure and rupture.

Failure to obtain sufficient water to balance transpiration results in permanent wilting and eventual desiccation of the leaves.

Plants sprayed with sodium pentachlorophenate immediately entered a state of permanent wilting. When the spray was washed off leaves within one hour after spraying, it was observed that the entire cutinized layer had been destroyed allowing a free diffusion of water from the cells to the atmosphere with resultant desiccation. No changes were noted in the root hair cells.

The number of samples examined and the lack of complete control preclude positive conclusions. However, the repetition of field observations warrants further experimentation.

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Note 1: - 24D - 20.97 pbw
245T - 20.97 pbw/4 lbs. 1 gal.
applied in form of emulsified amine salt-8 lbs./acre
Sodium pentachlorophenate - 25lbs/acre

Appendix I

Observation of sensitivity of plants to 24D-245T spray.

Affected

Goldenrod -
White Ash -
Butternut -
Red Maple -
Poison Ivy -
Wild Grape -
Sassafras -
Elderberry -
Spice Bush -
Tulip Poplar -

Not Affected

Choke Cherry -
Cedar -
Thistle -
Raspberry -
Aster -
Virginia Tea -

Operation "Sneeze

By Lawrence Slote[1] and William T. Ingram[2]

Operation "Sneeze" as might be implied from its name, is a study of one particular phase of air pollution, namely, that of pollen pollution. This phase of the study will attempt to reveal the mechanism responsible for the distribution of pollen grains in the lower layer of the atmosphere, namely, that layer which is in intimate contact with the man on the street. This layer will be referred to as the "breathing line layer".

This paper will attempt to bring forth by use of proper engineering acumen, factors to be studied in order to devise and evaluate effective ragweed control programs. The basic index of the control program's effectiveness is the daily pollen count. It therefore becomes necessary to know what factors are involved in obtaining a pollen count that means something.

In the New York City area, tree pollens appear in the atmosphere in early March, reach a peak during the first week in May, and disappear by the first week in June. Grass pollens first appear in mid April, exhibit no marked peak season, but persist at about the same concentration until late September or early October. The amount of pollen in the air at any given point or locality will depend on the quantity of pollen being emitted by various plants in the immediate vicinity and from neighboring sources.

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In order to use the pollen count as a means of evaluating ragweed control programs, it becomes necessary to sample the atmosphere to obtain a picture of the variation in pollen count both vertically and horizontally.

The sampling apparatus whether it be gravimetric or volumetric has to be located in the proper place. Buildings, trees, and other objects cause unadvoidable air turbulence and unpredictable air currents that will greatly influence the concentration of pollen being sampled. The present method of sampling, namely, the gravity slide does not present a true picture of the quantity of pollen existing in the atmosphere. First of all, this method is based upon the rate of fall of ragweed pollen which is assumed to be a smooth spere falling in quiescent air. Upon examining ragweed pollen, we notice that it is not a true smooth sphere but rather one that has spicules. The present collection method is not made in a still atmosphere but in one which is in motion. Because of these variations from the basic assumptions, it is improbable that the conversion from gravimetric to volumetric data means much. This is an important fact since pollen is sampled gravimetrically and then converted to the equivalent volumetric count which is reported. Since the air is in motion, it is probable that the pollen sample results more from impingement than settling.

The next interesting feature in the present system of pollen sampling is the location of the sampling equipment. The stations selected, are usually the roofs of the tallest buildings in the center of the area to be sampled. The severity of a hayfever attack is dependent on the quantity of pollen inhaled which is a function of the rate of inhalation of air in the immediate vicinity of the nose. It seems slightly foolish to go about sampling air at a level at least 20 times the height of the individual. It should be quite interesting to compare the pollen count at the "breathing line layer" with that of the 100 foot level.

Since pollen is released in a batch during the morning hours of the day, the present method of sampling over a 24 hour period only shows the effect of atmospheric dilution and not what concentrations the man on the street is exposed to in the hours during pollen release. Observations over shorter periods of time are needed to determine the variation before, during and following certain meteorological conditions and also to determine the momentary concentration at the "breathing line layer". It therefore becomes evident that the present method and location of sampling stations only present the overall atmospheric distribution of pollen while that of specific street level concentration to which the average individual is exposed is not recorded. It is in this latter category that further work has to be done in order to determine the concentration that the hayfever sufferer is exposed and also to furnish satisfactory and adequate means of evaluating ragweed control programs.

Since pollen is air borne, it is influenced by meteorological factors such as wind, precipitation, sunshine, etc,. The prime or major meteorological influence on pollen distribution is the wind. In his Master's

Thesis "Local Effects of the Atmosphere on Pollen Count in the Central Park Region of New York City" submitted to the Department of Meteorology, College of Engineering, New York University, Mr. James A. Child has shown for the 1946-47-48-49 pollen season that 39% of the total variance in the "adjusted pollen ratio" is associated with the wind variation. Similar studies can be made to show pollen variation with other meteorological factors.

In order to arrive at some general conclusions, the 1947-48-49-50 pollen count as reported in the New York World Telegram was subjected to an analysis of variance. The initial hypothesis was that there is no significant difference among the samples. From the analysis, this hypothesis was rejected at the less than 5% level of confidence. The chances are that if the samples were from a normal population, this great a variance would occur only less than 5% of the time by the operation of chance. It therefore appears to indicate that there are other factors that determine the distribution of pollen from year to year. Any one of the four years sampled can be broken down into an analysis to determine the correlation between pollen count and the associated meteorological conditions. It is beyond the scope of this paper to do such an analysis but it is the belief of the authers that this work will be done as soon as time permits.

In 1946, the Health Department of the City of New York began a city wide spraying program to control ragweed. It now becomes evident that one of the factors affecting the pollen count for the period studied is the effect of using herbicide. Accurate mapping of ragweed growth is needed in order to determine the magnitude of the source of pollen pollution.

Another factor entering into the variation of pollen count from year to year is the growth of new plants coming from old seeds. This growth takes place when the land is subject to new construction, erosion or any other operation which tends to denude or disturb the soil.

It has long been the authors' belief that a volumetric sampling device could be devised such that it would record the pollen per unit of air metered and so that the concentrations could be recorded chronometrically and correlated against the associated weather data. This instrument might be adapted for use on small captive balloons so that the air could be sampled vertically at given levels by lowering the instrument. This instrument could be arranged to face into the wind. This feature is extremely important since wind is the major factor in the distribution of pollen. This type of sampling station could be made mobile and spread around any given area so that the results would present a cross section both vertically and horizontally of the pollen concentration in the given locality. By proper correlation, the sampling data and meteorological conditions would show a clear picture of the mechanism of pollen distribution. In this manner, ragweed control programs may be evaluated as to effectiveness and sources of pollen pollution determined more specifically than at present. The correlated data from this particular system of investigation would be a powerful tool in the hands of the allergist.

The method also lends itself to the study of the overall distribution of pollen and perhaps might indicate whether or not a contiguous source is responsible for the pollen.

Let us sum up the factors that might influence the pollen count index as a means of evaluating the ragweed control program.

1. Variation in meteorological conditions
2. Effect of distrubing the soil
3. The present sampling techniques and instrumentation
4. Present estimation of ragweed growth areas

The above mentioned factors are subjects that the public health engineer must know or determine if he is to develop a practical ragweed control program whose effectiveness can be properly evaluated.

"Progress report on the use of herbicides to eliminate hand-mowing under guard rails and around traffic signs along New York State Highways"

Harry Iurka, Dept. of Public Works, Babylon, N.Y.
and A. M. S. Pridham, Cornell University

The objectives in this project are two:

1. to eliminate vegetation in a limited area under guard rails etc. for a period of six weeks or more.

2. or alternate - to restrain the growth of vegetation to a height of 18 inches or less for a period of at least six weeks.

Chemicals Used:

1. Tests conducted in 1949 included many materials. The most promising of these chemicals for eliminating vegetation for six weeks or more are included singly or in combination in 1950 tests.

2. Two new materials were added to the test in 1950. General chemicals 7 B-D and maleic hydrazide.

The following is a list of the formulations tested in three districts of New York State in the spring of 1950. Applications were repeated in two districts only. Atlacide and chlorox were applied only once in any district.

CHEMICAL MOWING TESTS
Amounts Per 1/2 Acre*

Material	Quan. Mat.	Fuel Oil	Water Gal.	2,4-D Gal.	Other	Remarks
Socony Vacuum PD 975 A	45 gal.			.75		
Esso WS 1896	40 gal.			.75		
Esso & PCP	30 gal.			.75		
Esso & TCA	30 gal.			.75		
Esso & PCP & TCA	30 gal.			.75		
Shell Chem. Co. Weedkiller 130	12½ gal.			.75	1 gal. ACX #337	
" 130	12½ gal.		17.5	.75	12.5# TCA	Requires Agitation
" ACK 170	50 gal.			.75	4 gal. ACX #337	
" " 337	4 gal.	41		.75		
Gen. Chem. Co. 7B-D	1.25 gal.	28		.75		

* Based on a vehicle rate of 7 mph. Applications were also made at 5 and 10 mph with same equip. & psi to give heavier & lighter rates of application.

Chemical Mowing Tests table cont.

Material	Quan. Mat.	Fuel Oil	Water Gal.	2,4-D Gal.	Other	Remarks
Chipman Chem. Co. Atlacide	200 lbs.		50			Treated $\frac{1}{4}$ acre only. Requires Agitation.
Atlacide	400 lbs.		80			Requires Agitation.
Chlorax Liq.	40 gal.					All Atlacide and chlorax applied only once.
TCA	$12\frac{1}{2}$#		30	2.5		
TCA 90%	$12\frac{1}{2}$#		30			
TCA	$12\frac{1}{2}$#		30	.75		
2,4,5-T Ester	2.5 gal.	25		2.5		Sprayed early before much growth started.
2,4,5-T Ester	2.5 gal.	25		2.5		All May except
2,4,5-T "	2.5 gal.		25	2.5		plants
2,4,5-T "	2.5 gal.		25	2.5	12.5# TCA	above.
Amer. Chem. Co. Non Volatile 2,4,5-T & 2,4-D	5 gal.	18				Treated 1/3 acre
Maleic Hydrazide	2 qt.		30	.75	$1\frac{1}{4}$oz.	Treated 1/4 acre

Methods of Application:

Formulations were applied as a spray. Fuel oil or water was used as a diluent to bring the formulations up to the desired volume which was 60 gallon to the acre where ever the nature of the formulation would permit. Two formulations were applied at less than 60 gallon; seven were applied at more than 60 gallon, per acre. Good coverage was attained when the spray gun moved over the guard rail at five mile per hour. Good results (a) 30 mph. in Babylon. See note added on page 1.

Sprays were applied by regulation tree spraying equipment from a single nozzle under pressure of 20 to 30 p.s.i. A truck and driver and two workmen were required for the spray application under experimental conditions. The spray gun employed was of usual typé so that by a quick turn of the handle the operator could open or close the spray gun. A single 45° elbow and appropriate bushings used to permit attachment of a Teejet nozzle with appropriate tip. The spray gun was approximately seven foot long permitting the operator to apply the spray close to the guard rail while the truck itself traveled on a hard road surface. The operator sat in the truck body and had clear view of the roadside. Treatments were applied under the direction of the district highway engineer. The actual application was by a regular foreman and maintenance crew.

The Schedule of Spray Application is given in Table 2

Table 2. Dates of application of chemical formulations to eliminate vegetation along guardrails in New York State 1950.

District	1st treatment	2nd treatment
Babylon	5/9 - 18	6/19 - 28
Syracuse	5/16 - 26	6/28 - 30
Watertown	5/29 - 6/9	

Observations:

Plots were rated as 1) satisfactory, 2) good or 3) not satisfactory. This was done in each district by the engineer in charge and also the authors who made inspections during the weeks ending 6/16 and 9/26. In general there was good agreement where objective 1 was considered i.e. elimination of all vegetation. None of the chemical formulations met the 2nd objective.

Table 3.
N. Y. S. D. P. W.
Chemical Mowing Tests
Record of Treatments Rated "OK" and "Good" 9/18-26/50

Material	MPH	Babylon	Syracuse	Watertown
Agronyl	5	OK		Good
Esso + TCA	5		Good	
Esso +PCP + TCA	5		Good	
Shell 130 + TCA	5	OK	Good	
	7	OK		
	10	OK		
Gen. Chem. 7B-D	5	OK	(Fair at 1 location, OK at 1 location)	OK
	7	Good		
TCA	5		Good	
	7		Good	
2,4,5-T + 2,4-D in oil in May	5			NG
	7			OK
2,4,5-T + 2,4-D in water in May	5			OK
	7			OK
	10			OK
2,4,5-T + 2,4-D + TCA in May	5	OK		OK
	7	Part Good		OK

None of the chemical formulations were completely satisfactory in all districts and under all experimental conditions. The treatments on which there was general agreement are listed in Table 3, which indicates two formulations of oil, TCA and 2,4-D to be effective in two or more districts. One formulation of TCA, 2,4-D and 2,4,5-T gave good results in two districts, one of which has a short growing season.

Uncontrolled vegetation in these tests included many grasses both perennial: orchard grass and cattails, and in the late summer, the annual grasses: crab grass, foxtails, and panniclo grass were the most common. Triodia and poverty grass were abundant on Long Island.

Broadleaf herbaceous weeds not adequately controlled, included milkweed, woody weeds included poison ivy largely regrowth because of limited coverage and on Long Island, smilax and Japanese honeysuckle. In general guard rails have been kept free of woody weed growth by regular maintenance and the problem of eliminating vegetation is confined to herbaceous types.

In Watertown area a single treatment with many formulations gave good control for the entire season. In the other districts where the growing season is longer, two applications were needed. In 1950 the two treatments were required. The major difficulty during the late season comes from annual grasses. Contact herbicides applied at an appropriate time might prove satisfactory for the second treatment and be less hazardous to farm crops as well as being less expensive.

Summary:

The majority of all herbaceous vegetation growing under guard rails along highways can be eliminated for a six week period by timely spraying with herbicidal formulations.