In cooperation with the Division of Cotton and Other Fiber Crops and Diseases (Cotton Division) of the Bureau and the Mississippi Agricultural Experiment Station plans are being made for more work in the South on serious weeds of the cotton areas. One of the first problems to receive attention has to do with grass weeds in cotton which cause so much concern in the areas where mechanical pickers are being used. When grass grows in or between the rows of cotton it causes a real hazard to the crop at harvest since the trash and fiber from the grass becomes mixed with the cotton and at present no machines are available for making separation. This appears to be one of the very serious problems confronting mechanical harvesting, if high quality fiber is to be obtained. It is the plan to locate a man at the Delta Branch Experiment Station, Stoneville, Miss., to work on this project. For this year then, the new Division and the expansion of work in New Jersey and Mississippi used up all of the additional funds obtained.

For the next fiscal year (i.e. 1951) plans are being developed for work with weeds that are serious in the vegetable regions, probably increasing and strengthening the work in the Northeastern region and inaugurating some new work in the South. In addition to this, consideration is being given to strengthening the work in the cotton area by starting some work in the Coastal Plains and in the San Joaquin Valley of California.

Considerable interest is developing in a project on brush control and range management in the Southwest. As you may know, mesquite and other brushy plants are becoming an extremely serious hazard to the range lands of Texas, Oklahoma, New Mexico, and adjacent states. Considerable progress has been made on the control of sagebrush but the mesquite problem is still unsolved, as to date the research work has been totally inadequate. Once the brush is killed the reseeding and proper management of the range becomes important, so as to provide adequate grass cover as well as to prevent regrowth of the brush.

Of more interest to this group is the matter of the control of weeds in fresh water lakes, recreation areas, etc. A Bill convering such work was introduced into the Congress by the Honorable Mr. Sheppard of California, with a title of: "A bill to provide for research, studies, investigations, and experimentations into the problems of aquatic weed and other water plant infestations." The provisions of this Bill are as follows:

> "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it is the policy of Congress to find remedies for the serious problem of aquatic weed invasion and other plant infestations which confront private owners of freshwater lake fronts and salt-water shore lines, municipal water and sewer departments, State and county conservation commissions, public agencies, industrial water users, and other users of inland waterways. Among the damages and injuries caused by inroads of this aquatic plant life are (1) interference with the use of waterways and inland water streams and lakes for navigation and water supply; (2) the depletion or destruction of oyster beds and sources of fish and waterfowl feeding; (3) the creation of health hazards through stagnation and production of offensive odors; (4) the displacement or destruction of water courses for boating, fishing, and other recreational purposes; and (5) the spoliation of municipal and other public scenic and landscape improvements."

"Section 2. The Secretary of Agriculture is authorized, independently, or in cooperation with public or private agencies, and institutions, or individuals to engage in research, studies, investigations, and experimentations into the problems of aquatic weed and other water plant infestations."

"Section 3. There are hereby authorized to be appropriated such sums as may be necessary to carry out this Act."

This bill was introduced in the House of Representatives on August 5, 1949, and referred to the Committee on Agriculture but no further action was taken before Congress adjourned. From this you will see that interest in weed control research continues in the Bureau, and at the same time more states are initiating projects. Research and Marketing Administration technical committees are active in the four regions of the United States. In the North Central Region the weed project has been activated and the technical committee given travel money for 1950.

A Weed Bibliography

From time to time many of the men working on weed control research have felt that there was an urgent need for a separate bibliography covering this field. Reports of work and technical papers are coming out so rapidly that it is impossible for anyone to keep up with all of them, therefore some sort of a bibliography would undoubtedly be of considerable value. The Western and the North Central Weed Conferences have considered this matter with considerable care and have suggested that the Bureau of Plant Industry, Soils, and Agricultural Engineering should take the responsibility of such a bibliography. Workers in the Bureau of Reclamation, Department of Interior have also raised the question of the need of a bibliography and they too have suggested that it would be very desirable to have our Bureau take this responsibility

A number of workers are already keeping bibliographies and in one or two cases these are being distributed to limited lists of cooperators. This is an extremely worthwhile idea; on the other hand, there seems little use for more than one bibliography especially if each one covers essentially the same field. For this reason there is considerable argument in favor of a central project covering the work.

It is fine to decide that there should be a bibliography and suggest that it be initiated. On the other hand, the matter is not so simple as this because it will be a real task and we are not clear just how to proceed. In the first place, this may be a matter for a library to undertake, possibly the U. S. Department of Agriculture library. It would be a relatively simple matter for them to catalog all articles and publications on weeds in a separate list and then make this list available to those interested. If this were done it would probably be possible for them to list only titles and authors. Some workers feel that in addition to the conventional listing of authors and titles that there should be a brief statement of just what is covered in each publication, or the listing of papers under general subjects. This, of course, would be much more helpful to the workers, although it would be more difficult to develop. Possibly, if this last suggestion were to be followed someone who had had experience with weed literature could be assigned the task of keeping the bibliography up-to-date. This individual could prepare brief statements or summaries of what is contained in each of the citations. Then, at stated intervals, it would be possible to have this bibliography mimeographed and made available to all interested workers. Naturally this would cost money and at present the funds would have to come from the regular research allotments.

Since the Bureau is more or less committed to make a start on this problem we are asking your suggestions as to just what should be done. The other weed conferences are giving more consideration to this matter and after suggestions are received a definite effort will be made to get something under way.

Integration of Screening Tests

At the present time new herbicides are coming out so rapidly that it is almost impossible for any group of workers to keep up-to-date. Many of the new chemicals are being used in the field immediately and, of course, some of them prove to be very promising while others are just as unpromising. In some cases, so-called preliminary or screening tests are being conducted in pots in the greenhouse, or in the field with very small plots. In these experiments the new chemicals are tested in a preliminary way as to their effects on one or two test plants. Only those chemicals showing promise are then used in field plots. This makes it possible for the fieldmen to avoid tying up valuable space and time with chemicals that may prove to be of no value. It is known that these preliminary tests are being carried on at a number of locations and in some cases the same chemical or type of chemicals are being tested at several locations and on the same test plants. It would seem that there is a real need for closer integration of this work and possibly a summarization of the findings. In this way it would be possible for a more complete coverage of the new herbicides that are available and at the same time would make possible a useful preliminary evaluation of each. It would then be necessary for the fieldman to work on only those which have shown some promise.

Another phase of this same problem has to do with the inability to continue experiments on a given herbicide for a period of years. Often tests are started in the field one year and let us assume that the results are rather promising. The next year the field worker wishes to repeat his experiments and when he tries to obtain a supply of the chemical he is told that it is no longer on the market but in its place something else has been substituted. This new formulation may be slightly different from the old one and this raises a question as to the continuity of experiment. This situation is extremely annoying to the worker and he becomes reluctant to start new experiments with chemicals until he has some assurance that they will be on the market for more than one year. If more carefully planned preliminary tests were available to give the first information possibly some of this confusion would be avoided. In other words, it would be best to keep the material in a screening test until such time as there was some assurance that a constant supply would be available.

Another solution to this dilemma might be to have some central agency, such as the Bureau of Plant Industry, Soils, and Agricultural Engineering make up the pure compounds of the basic active ingredients and keep these available for use by all workers cooperating in the weed program. By using the pure compounds with one or two standard solvents it would be possible to make comparisons on a year to year basis and also use these compounds as the basic standard for comparison of commercial formulations.

Integrated Research

Another matter I wish to discuss with you has to do with a closer integration of weed work in this Region. As you know the research committees of the Western and North Central Weed Control Conferences meet for 1 or 2 days prior to the annual conference to summarize the data available and to prepare a so-called policy statement. Dr. Grigsby, of the Michigan Agricultural Experiment Station, of our Division was chairman of the research committee of the North Central Region last year.

It is my belief that the research workers of this region could well afford to devote 2 or 3 days (at the time of the annual conference or at some other convenient time) in (1) reporting, digesting, and interpreting data available, and (2) planning experiments for the following year. Out of such a meeting might well come a summary statement of current results. It is well remembered that the question of a summary statement was discussed here last year and the committee decided against it because of the diversity of conditions and crop and the difficulty of the task. The difficulty of the job is fully recognized, since it can not be done well in a few hours. On the other hand, the material published in the conference report will be read and interpreted in various ways, and who is better able to summarize these reports than the workers in this area. In the North Central Region the summary serves a very useful purpose in getting research people to effectively digest and evaluate the mass of information presented to the conference. In effect it serves as a guide also to commercial companies operating in the region and the summary statement has been reprinted and widely distributed by the companies.

This group might well give some consideration to establishing some uniform tests. Experiments of this type have proved to be very effective in other areas, as for example the results obtained on bindweed control. At present several uniform experiments are carried in the Middle West, and each is giving valuable information. It may not be out of place to mention that uniform tests of varieties of cereal crops have been used for more than 20 years and have proved to be invaluable in determining the value of new material in a relatively brief period, as well as supplying more fundamental data. The number of uniform tests should be kept at a minimum so as not to take up too much space and time at any one station. To be most effective these tests must be carefully planned, as well as carefully carried out.

I am fully aware that this proposal is a big and difficult job, but in my opinion the probable satisfaction from such an endeavor would justify the effort. It certainly would serve to increase public confidence in the whole research program. It does not mean that any individual worker would be limited in his activities in any noticeable manner because the uniform experiments would be suggestive only. If a start is made in this direction it should be on a modest scale, until it is found that the idea has merit. Undoubtedly when the Research and Marketing Administration weed project gets under way in this region some of these ideas can be given more consideration, and could well become a part of the program.

Precautions Should be Emphasized

In an area where there is so much mixed farming it is highly important that the use of certain chemicals does not get out of control. Workers in this area are, in my opinion, to be highly commended for the care they have exercised in making recommendations and in cautioning prospective users concerning the dangers in the use of certain chemicals. Each of you is well aware of the disastrous results which may follow if some of the more potent chemicals reach susceptible crops. Damage has ranged from a few flowers or vegetables in a back yard to serious damage to crops over a wide area. Had it not been for this care drastic legislation and regulations would undoubtedly have been enacted. All of us, I am sure, are in favor of such laws as are necessary but I am equally sure you will agree that as far as possible it is better to take care of these matters voluntarily. In traveling over the country I have heard of instances where herbicides were still being recommended and sold by individuals who knew little or nothing about the effects of the chemicals, or proper ways to use them, and less about the weeds and crops involved. I am sure that our better informed commercial associates are well aware of these facts and realize the need of caution in promoting sales campaigns until such time as sufficient data are available to make safe recommendations possible. It may not be possible to sell as much chemical this year, but a lot more will be sold in the years to come if over selling is avoided. There is a continuing need of full consideration of more careful wording of advertising copy, and of the directions accompanying the herbicides. In some cases precautions are not being given sufficient emphasis. All persons making recommendations for the use of chemicals should be especially careful of all statements released.

Summary

It has been a real pleasure to appear before this Conference again. It has been most helpful in bringing me up-to-date on your latest achievements. Your suggestions on the matter of a weed bibliography as on the other items mentioned are solicited. It is hoped that none of you will take offense at any statements made regardingthe research work because they were not meant as criticism in any sense of the word. They were made as constructive suggestions in order to try to stimulate your thinking. You have an opportunity to make the weed work in this region an outstanding example of cooperative research work. You are well started in the right direction and I feel sure that individually and collectively you have the vision and desire to move forward.

THE PERSISTENCE OF HERBICIDES IN SOILS

by
A. G. Norman and A. S. Newman[1]

There are a number of reasons why the persistence or, more correctly, the fate of herbicides in soil is a matter of considerable interest at present. The widespread adoption of herbicidal practices involving 2,4-D and related compounds means that substantial amounts of these materials in one form or another find their way onto the soil. This may be incidental to spray applications to the foliage, or intentional as in pre-planting or pre-emergence treatments. Even though the application rates of the newer herbicides are low, their fate in the soil cannot be ignored. The agronomist is anxious to know whether chemicals reaching the soil can long persist and be cumulative so that subsequent plantings may be adversely affected, or whether the compounds are ephemeral and soon disappear. He is anxious to know whether additions to soils at herbicidal rates are sufficient to affect in any way the physical and chemical properties of the soil or the activities of its microbial population that might have repercussions on the welfare of the plant. Moreover, in the case of pre-planting or pre-emergence treatments he is directly interested in the fate of the material applied inasmuch as the efficacy of the practice and its usefulness for a particular crop and environment may hinge on this very characteristic. Rarely has this information been available when the practice was empirically developed. Moreover, as will appear later, it is by no means certain that the rate of disappearance of a later treatment can be confidently predicted from a knowledge of the fate of the initial application on the same plots or field. There would, therefore, appear to be a strong case for more careful considerations of the behavior of candidate herbicides in soil before firm recommendations for use are made.

There are several reasons why the effective concentration of a compound added to soil may be reduced. The major causes are (a) removal downwards by leaching, (b) inactivation through reaction with soil components, and (c) decomposition by soil microorganisms. These will be discussed under two headings. Recent work with 2,4-D and related compounds will be used for illustration of the operation of these factors. The principles are, however, broadly applicable.

Leaching and physical inactivation. The importance of leaching in the removal of herbicides from soil depends on the solubility of the agent, the amount and distribution of the rain, and the character of the soil. 2,4-D, either in the acid form or as a salt or ester, is apparently sufficiently soluble so that it readily moves downward in

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[1]Biochemist and Soil Scientist, respectively, Biological Department, Chemical Corps, Camp Detrick, Frederick, Maryland.

the profile (2, 5, 7). Textural differences influence the rate of downward percolation of water and, therefore, of herbicide but do not appear to have direct effects on the movement of 2,4-D. Salts of 2,4-D no doubt undergo exchange with the clay colloid so that it is not to be expected that the cation involved will be of much consequence. The active herbicide, being anionic in character, does not appear to enter into exchange reactions or fixation reactions with the clay colloids. There is some evidence, however, of interaction with the organic fraction of soil or with organic residues whereby a measure of retention against leaching is exhibited. This herbicide may, therefore, leach more slowly from organic soils than from mineral soils. The nature of the reaction between 2,4-D and organic residues is not established nor is it known whether the activity of 2,4-D so retained is manifest at its full level. Experiments by Weaver on contratoxification (16) with resin anionic exchangers suggest that the activity would be reduced. In summary it may be said, therefore, that in normal soils leaching of 2,4-D and related herbicides may readily reduce the concentration in the surface horizon, and that physical inactivation through reaction with soil components is not ordinarily a significant factor.

Decomposition or microbiological inactivation. The soil population is capable of utilizing a great diversity of natural organic compounds and by oxidative degradation reducing them to simple end products such as CO_2, H_2O, nitrate, etc. Herbicidal chemicals are likely to be completely foreign to the normal economy of the soil and their oxidation will only occur if there are organisms present with appropriate enzyme systems to accomplish the hydrolytic and oxidative steps required. The soil is a great reservoir of microorganisms; many species that are not at the time active remain viable in small numbers to spring into prominence when an appropriate source of energy is present. Some herbicidal compounds may well have inhibitory or bactericidal properties. If added to soils such compounds might repress or inhibit normal activities of the soil population. Studies with 2,4-D have shown that in culture solutions and on solid media the concentrations necessary to inhibit representative soil organisms are high (11) and far above those which will cause injury to plant growth. In soil, applications at the ordinary rates do not appear to influence adversely either carbon dioxide production which is a measure of general microbial activity (11), numbers of bacteria (14), or nitrate production (9, 14). These findings cannot be said to prove that none of the normal functions of the soil population are affected but taken in conjunction with the relatively high tolerance level found in pure cultural studies, they provide strong presumptive evidence.

Studies on the persistence or disappearance of 2,4-D from soil necessarily involve tests for its presence. The simplest procedure is, of course, to make a sequence of plantings of an appropriate seed at intervals after treatment in order to determine when the concentration has been reduced to a level that will permit seedling development with or without some morphological abnormalities. Methods of extraction and bioassay using a root elongation test provide more strictly quantitative data (13) as does a physical method based on absorption spectroscopic measurements following extraction (15). The last is not as sensitive a method as the bioassay.

Using one or other of the principles just described, various workers have determined the persistence of 2,4-D in soils under field, greenhouse and laboratory conditions. Their answers may appear at first sight to be inconsistent and contradictory. Even under field conditions a range of 10 to 12 days (3, 4) to many months (8) has been reported. This is, however, not inexplicable because of the great diversity of microbiological environments and populations found in soils in different locations. Controlled experiments (1, 6) have shown that the usual factors such as temperature and moisture that influence general microbiological activities are operative in 2,4-D degradation. Persistence is likely to be greater in cool or arid soils than in warm moist soils. It is to be remembered that in most areas the temperature and moisture content of the soil are distinctly below the optimum for maximum microbial activity.

The addition to soils of materials enhancing microbial activity, such as manure (1), leaf mold (10), or other energy sources, appears to accelerate the decomposition of 2,4-D. It may further be presumed that the rate of disappearance of this compound would be greater in surface soils where biological activity is most intense than in subsurface soils that normally possess a somewhat more restricted population. The amount of 2,4-D added is also a factor, as might be expected, though within the range of treatments ordinarily employed this may not be of great significance. In a greenhouse experiment at optimum moisture content the persistence of 2,4-D at rates of 2.5, 10.0, and 50 mg. per lb. was 8, 11, and 21 days (12).

Less than adequate consideration has been given to the microbiological factor in persistence. If, as indicated above, the addition to soil of a wholly foreign type of energy source causes a group of organisms previously unimportant to spring into prominence and to accomplish the degradation of the material added, the subsequent fate of these organisms is a matter of great interest. If they remain viable in significant numbers, subsequent addition of the same material may be more rapidly utilized since the initial lag phase, during which the population increased from its originally small size, may be dispensed with or shortened.

Studies along these lines have shown that in soil to which 2,4-D had been recently added and from which it has disappeared, a later addition was removed more rapidly (Table 1). As yet, convincing field experiments on this point have not been carried through, though in soil samples from plots treated in previous seasons, further additions of 2,4-D in the greenhouse, proved less persistent than in previously untreated soil (Table 2).

Table 1. - Persistence of 2,4-D, applied at a rate of 10 mg. per pound of soil, as affected by previous treatment. Persistence determined by the cucumber root elongation test. Laboratory experiment.

Previous treatment	Persistence in days
50 mg. 2,4-D per lb. soil	8
10 mg. 2,4-D per lb. soil	8
2.5 mg. 2,4-D per lb. soil	15
None	>20

Table 2. - Persistence of 2,4-D, applied at a rate of 5 mg. per pound of soil, as affected by previous treatment. Soils were sampled in September 1948 after disappearance of the original treatment. Persistence determined by cucumber root elongation test.

Previous treatment	Persistence in days
20 lb. 2,4-D per acre, June 1948	6
20 lb. 2,4-D per acre, July 1948	6
20 lb. 2,4-D per acre, July 1947	9
None	20

This is a finding of considerable practical importance inasmuch as it raises the question as to whether a weed control practice such as pre-emergence soil treatment, the duration of effectiveness of which is dependent upon persistence, may not be less satisfactory when made to the land a second year or even after an interval longer than this. Perhaps in practice it may be necessary to employ a different compound in the second or later season. There is an analogy in this with the situation that has developed in certain areas where repeated DDT treatments have become less effective because of the development of resistant species of flies or mosquitoes. If long duration of effectiveness is not an important characteristic of the practice involving soil treatment as may well be the case, a somewhat higher application rate in the second or subsequent seasons may be all that will be needed.

GENERAL STATEMENT

The persistence of organic herbicides, such as 2,4-D, in soils depends, on the one hand, on their physical properties and chemical nature, and on the other, on the microbiological environment of the soil. In humid regions the concentration of soluble herbicides in and near the surface may soon be reduced by leaching if they undergo no immobilizing reaction with the soil colloids. Equally, in soils in which microbiological activity is vigorous, decomposition may be rapid if the compound is biologically oxidizable. Microbiological inactivation may, however, be delayed because few individuals in the population are able to effect the specific oxidations initially required. Accordingly, at first test a compound may appear to be more persistent than will be the case with later applications to the same soil when adequate numbers of the necessary organisms are present. Persistence of herbicides in soils is likely to be greatest under arid conditions when the factor of leaching is inoperative and microbial activities are checked because of low soil moisture, and least where both rainfall and soil temperatures are high. Intermediate conditions are provided by cool humid climates or sub-humid areas with wide seasonal temperature differences. It is to be expected, therefore, that the results of field studies on persistence carried out in different parts of the country may appear inconsistent, and the reliability of soil herbicidal applications, such as pre-emergence treatments, may be questioned because of the interplay of these factors. Generalizations cannot be safely made without reference to soil and climatic conditions.

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WEED CONTROL RESEARCH MOVES FORWARD

K. S. Quisenberry [1/]

At the Third Annual Northeastern Weed Control Conference held in New York City in 1949, I was given an opportunity to outline in some detail the history and development of the weed control research project of the Bureau of Plant Industry, Soils and Agricultural Engineering conducted in cooperation with various State agricultural experiment stations in the United States. Mention was made of the work on the control of bindweed which was the first started. This was followed by projects on nut grass control in the South and on weeds on irrigated lands of the West. Next, the new Research and Marketing Act project entitled "To establish a cooperative national research program to develop practical methods and equipment for weed control" was explained in some detail. Some of the preliminary results obtained from this work were reviewed briefly. Now it is my wish to bring you up-to-date on developments in the Bureau of Plant Industry, Soils and Agricultural Engineering relating to the cooperative weed control work, as well as to tell you of some of the plans for the future. Also, there are several points I wish to discuss with you, in order to enlist your suggestions and advice as to what may be the best course to follow.

New Cooperative Projects

For the current fiscal year (i.e. 1950) the Bureau was granted additional Research and Marketing Administration funds, but at the same time there was a reduction of approximately 5 percent in the regular funds. This necessitated some reorganization, but new plans are being pushed forward. First of all, a Division of Weed Control will be set up as a separate and distinct unit in the Bureau. As you now know, Dr. R. L. Lovvorn, stationed at Raleigh, N. C., has been appointed as Head of this Division and he will take over his duties on January 15, 1950. As the name indicates this Division will coordinate all of the research work on weed control in the Bureau regardless of the crops involved, as well as the work on weed control machinery. It is expected that the same general policies that have been followed in the past will be continued, at least until such time as Dr. Lovvorn has an opportunity to become familiar with the work under way. Certain reorganization at Beltsville will be necessary since L. S. Evans transferred to the Agricultural Research Administration staff and Mr. Kephart has retired.

At the New Jersey Agricultural Experiment Station the cooperative work has been strengthened since the position there was made a full-time one. This will make possible the broadening of the work in New Jersey, and possibly in the Northeastern region.

1/ Head Agronomist In Charge, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture. Presented at the fourth annual meeting of the Northeastern Weed Control Conference, New York, N. Y., January 4, 1950. The speaker is pleased to acknowledge the helpful suggestions and criticisms given by S. C. Salmon and L. S. Evans during the preparation of this paper.

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SOME ENGINEERING DEVELOPMENTS IN WEED CONTROL[1]

William E. Meek[2 3]

Weed control is a problem that has confronted farmers for centuries. Great strides have been made in equipment through the years but basically there is little difference between the thorny bushes which early man pulled through his fields and the cultivators of today. They both mulch the surface and uproot some weeds and grass. True, however, the modern implements cover more acreage and are more efficient allowing a most important timeliness to operations.

The problems of weed control will be vastly different according to the section of the country, the crops grown, climatic and even seasonal conditions. Most of the work done in the South has been with cotton, this being the principal money crop. Both broad leaf weeds and grasses are prevalent in Southern fields and selective chemicals have not, as yet, been developed for weed control in cotton. It is hoped that some of the basic developments in cotton may be used with other crops in other areas. Experience shows that this is true in certain operations.

Weed control encompases many operations in the making of any crop. Drainage or water control, clean cultivation through the years, properly cleaned seed, summer fallow--all of these and others have their bearing on the problem, but do not come within the scope of this discussion. It is with new developments, principally in the Engineering phases, that we are interested.

To get the most from his modern equipment, the farmer must have his methods as modern as his machines. He must have, or be willing to acquire, the necessary "know-how" to operate his machines in the most efficient manner. Good farming today, as always, has no substitute.

The modern farm tractor equipped with pneumatic rubber tires is capable of operating at relatively high speeds. In order to utilize to the fullest the efficiency of the tractor, precision farming is necessary. To attain precision, uniformity is a must. Only with proper supervision and attention to details can uniformity be attained in the highest degree.

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[1] A progress report of a cooperative study between the Mississippi Agricultural Experiment Station, Delta Branch and the United States Department of Agriculture, Bureau of Plant Industry, Soils and Agricultural Engineering and Divisions of Agricultural Engineering in which certain phases were carried on under the Research and Marketing Act of 1946.

[2] Senior Agricultural Engineer, U.S.D.A., Bureau of Plant Industry, Soils and Agricultural Engineering, Regional Cotton Mechanization Project and the Mississippi Agricultural Experiment Station, Delta Branch.

[3] Fellow, American Society of Agricultural Engineers.

In order to achieve this so important uniformity a "Line Diagram Method of Setting Farm Machinery" has been developed[4]. By the use of this method the Agricultural Engineers at the Delta Branch Experiment Station, Stoneville, Mississippi are enabled to set such machines as four-row cultivators in the shop and without further adjustment in the field, cultivate young cotton, corn, soybeans and like crops at speeds of from 5 to 6 miles per hour. Not only is greater efficiency attained, but the class of work done is far superior to that of the farmer who attempts to set his implements in the field. It is only through such methods that we have been able to approach the greatly desired uniformity.

First in a discussion of weed control is mechanical cultivation with various types of cultivators. Inasmuch as mechanical control at the present time is carried on simultaneously with other methods such as chemicals and flame, it has a most important effect on the efficiency of the others. With either chemicals or flame ridges, trenches, clods or any other deviation from uniformity in the surface of the ground is most undesirable. Proper setting of the mechanical cultivator is, then, of prime importance.

The type of sweep or ground working equipment used will vary with the crop and territory. If sweeps are used, they should be of a type suited to the modern tractor with its higher speeds. It has been found that sweeps with a relatively broad angle and low crown are preferable when high speeds are to be used. These sweeps throw the minimum amount of dirt to the drill and leave the "middles" free of weeds, but smooth and uniform. The modern tractor cultivators are of the parallel action type and when the sweeps are set FLAT on the floor of the diagram, it will be found that they will all take the same angle of pitch for penetration when in the working position. They will be self-sharpening, wearing down to maintain their original angle and consequently longer lasting.

The new rotary weeder attachments[5] mounted between the cultivator gangs serve to cultivate in and around the young plants and at the same time are most efficient fenders. As the plants grow in height the inner hoe wheels may be removed and the outer wheels still serve as fenders for several more cultivations. Another advantage of the weeders is that, the sweeps being set outside the outer wheels, they serve as a visual above ground gauge as to the location of the wing of the sweeps and so allow the operator to increase his rate of travel. Being independant of the cultivator gangs, none of the ground working equipment need be removed and the weeder is free to float along the drill. In the early stages of cultivation these weeder attachments speed up and at the same time increase the efficiency of the operation.

Cotton, out principal crop, is most susceptible to damage from many of the chemicals so effective in other crops. Pre-emergence sprays have proved satisfactory in plots, but because of the usual weather conditions at planting time, cannot be relied upon and as a consequence are not to be recommended. Post-emergence spraying for weed control apparently offers the most promise in cotton as well as many other crops.

The testing of materials for weed control is a slow and laborious procedure. Supplementing field plots with greenhouse screenings is indicated due to the acreage that would be required, the labor involved and the length of the growing season. To facilitate this testing a chemical weed control testing table was designed and built[6]. In the design of the table basic requirements were set up so that field experiments could follow closely any tests made in the greenhouse. Pressures, jet size and spray patterns, location of the jets and the speed of travel all had to be controlled if they were to be duplicated later in the plots. The table consists of a metal top with holes cut to accommodate one replication of ten pots. A carriage equipped with a pressure pot of one quart capacity complete with one or more spray nozzles is carried past the pots spraying the plants in the manner desired. A chain with one projecting lug propells the carriage down the table between two tracks. This chain is driven by a 1/4 horsepower electric motor through a "V" belt type transmission allowing speeds on the drive shaft of from 30 to 400 revolutions per minute. One revolution of the drive shaft moves the chain one foot along the table. A tachometer mounted on the end of the shaft then gives the feet of travel per minute, according to the revolutions recorded. With a known speed, a known pressure and a selected spray nozzle it is a simple matter to apply the material being screened in the greenhouse at the same rate per acre and miles per hour as will be encountered in the field plots.

Pressure to the pressure pot on the traveling carriage is supplied from the tank of a standard compressed air type spray rig used here as an air compressor. Pressures are regulated through a moisture trap and regulator as are furnished with standard paint spray outfits. All hose connections are of the quick coupler type.

In operation the spray nozzle or nozzles are selected and installed. The transmission is set for the desired miles per hour of travel which is usually that of the speed of the tractor in one of its working gears at full throttle. The pots containing the plants are placed in the table. The material to be tested is put into the pressure pot and the quick-coupler attached for air pressure. The valve controlling the air is opened, the switch on the motor and the carriage then moves past the post spraying the plants with the material, The use of this table allows all variables except soil types and weather conditions to be eliminated.

In actual operation four men have been able to test as many as one hundred replications of pots easily in one day. Two of the men are common laborers who bring the pots to the table and remove them back to the greenhouse. This great saving in time allows the screening of many materials and their subsequent elimination from the field tests.

The table also lends itself most admirably to the testing of insecticides for the determining of rates of application and reaction of the plants to the toxicant

For the application of the previously screened material to the field plots, a light two-row general purpose tractor is used equipped with a shovel cultivator as is used in the area on the front, a flame cultivator on the rear and a spray system complete with tank, strainers, pump, valves, etc. One tractor then serves for all the weed control procedures.

In cotton it is important that the chemicals contact the leaves of the plant as little as possible if damage is to be minimized. To accomplish this application of the spray material to the base of the plant and across the drill, shoes were designed to carry the spray nozzles, one on each side of the row. Should a ridge, clod or other obstruction be encountered it is important that the shoe be free to pass over this obstruction with little or no change in the angle of the spray pattern. As fan type nozzles are used, if the angle of the pattern is changed from its setting of parallel to the ground, damage is apt to result well up into the plant. The spray shoe is, therefore, constructed with a parallel action so that though the jet may be higher from the ground it always remains in the same horizontal plane.

Mimeographed sketches show both the general lay-out of the screening table and the application shoes. It will be noted that the parallel arms of the shoes are constructed in two ways. In one, the arms are vertical while in the other they rise from the shoe at an angle of 45 degrees. This gives an off-set to the shoe for additional clearance when needed.

The calibration of spray machines is important as jets will vary in their output because of manufacturing tolerances and pressures. For ease in calibration of spray equipment a formula has been evolved. This formula is expressed as follows:

$$\frac{\text{Gallons per hour}}{\frac{\text{Swath (inches)} \times \text{M.P.H.}}{100}} = \text{Gallons per acre}$$

The gallons per hour are determined by operating the equipment, usually with water, for six minutes which then gives the output per hour when multiplied by ten. At the end of six minutes operation the supply tank is refilled to its original level to determine the output for the period.

One hundred inches wide and one mile long equals one acre so the swath width in inches divided by 100 gives the acres per mile. The miles per hour of the tractor can be determined by clocking a measured distance with a stop watch or, if extreme accuracy is not necessary, by using the rated speeds as given in the owner's manual. All operation should be at full throttle in a given gear speed.

In operation, then, if we measure an output by the system as .72 gallons in six minutes; the tractor traveling at 3 miles per hour and covering two 40-inch rows we have for our formula:

$$\frac{.72 \times 10}{\frac{80 \times 3}{100}} = \frac{7.2}{2.4} \text{ or } 3 \text{ gallons per acre}$$

The formula of 100 inches wide and one mile long equals one acre is a quick, simple and accurate method of computing the duty of machines regardless of their type.

About 1940 Colonel Price McLemore, a planter of Waugh, Alabama, began his serious experiments with flame as a means of weed and grass control. His, and other early model flame cultivators, used kerosene or diesel oil for fuel with production burners as used by industry. An air compressor furnished the means for atomozation of the fuel. The machines were bulky, expensive and it was extremely difficult to keep the burners lit. On the slightest provocation one or more of them would go out so that very spotty results were usually the rule. In 1945 at the Delta Branch Experiment Station, where research with flame had been in progress for about two years, an ignition system was added to the burners[7]. This consisted of either a distributor or magneto with automotive type spark plugs in each burner. This attachment greatly increased the efficiency of the liquid fuel burners.

Also in 1945 Harold T. Barr, of the Louisiana Experiment Station began experiments using the L-P gases, butane and propane, as fuel. His first machine was mounted on an old horse-drawn cultivator and carried the fuel in a commercial cylinder and employed burners made from pipe. This burner changed the trend in flame cultivation and the "Barr-type burner" became standard with all manufacturers. Many modifications and improvements were made on the original design, but basically it remained the same until 1948.

In 1948 Stewart Poole, Research Engineer of the International Harvester Company, conceived the idea of using a standard spray nozzle as an orifice in a flat-type burner and brought to the Delta Branch Experiment Station a pilot model machine. Press of other developments suspended research on this equipment by the International Harvester Company and their experimental machines were left at Stoneville for use by the Agricultural Engineers in their experiments.

The burner as developed by Poole was most efficient, but heavy and expensive. Development was started to reduce the cost of manufacture, decrease the weight and increase the efficiency of the burner if possible. As a result of these studies, a new burner was developed, formed of sheet metal and incorporating the basic principles of the original burner, but giving greater efficiency and higher operating speeds[8].

The burner opening is 8 inches long and $5\frac{1}{2}$ inches wide, tapering from $1\frac{1}{2}$ inches in depth at the rear to $\frac{1}{2}$-inch at the mount. The orifice employed is a spray jet with a 40-degree spray angle.

The burner is set at an angle of 45 degrees to the base of the plant and adjusted horizontally and vertically so that the flame strikes the drill about one inch from the plants. Two burners per row are used, one on either side and staggered so that the flames do not meet. When once set the burners maintain their adjustment which is of prime importance when unskilled labor must be used to operate the equipment.

Each spray nozzle has its own strainer which helps reduce to a minimum stoppages from foreign matter in the fuel and results in more even control and a saving in time.

The tips of the nozzles are easily changed or replaced, allowing the flame to be varied according to the orifice size. Tips used will vary from those delivering .3 gallon of water per minute on up to those with a .6 gallon capacity. Size of the orifice used will be dependent upon the size of the plants, the amount of infestation and the pressure used.

Pressures will usually vary from 30 to 40 pounds, though with heavy infestations of grass, it may be desirable to increase the pressure to 50 pounds, in order to drive the flame into the mat of vegetation or to increase the rate of travel. Fuel consumption per acre will vary with orifice size, pressure used and speed of travel. With L-P gases selling to the farmer for 10 cents per gallon, the average cost of each flaming per acre will be about 60 to 70 cents for fuel.

Cotton, when small, has a waxy outer coating which seems to resist the aromatic oils used as herbicides. As the plant grows in size this coating disappears and a corky layer will begin to form under the outer bark. The plant will usually be about 3/16" in diameter at its base when this corky layer is well enough formed for flaming to commence. Apparently this corky layer, while protecting from flame damage, has a tendency to absorb the oils and may limit their use.

Flaming is started as early as is possible without damage to the plant and continued on through the growing season. The number of flamings necessary is dependent upon seasonal weather conditions. A dry season with a light growth of weeds may require only three or four applications of the flame while a very wet season with a subsequent heavy growth may require three or four times as many.

Late control is vitally important where mechanical harvesting is to be employed and late flamings have proven to be most beneficial. Farmers, however, are not always able to get their equipment through the heavy vegetation of the crop without damage. This condition may also exist during the late mid-season period.

To allow equipment for weed control as well as for insect control and defoliation to be used in the crop without damage, wheel fenders for the tractors have been developed[9]. The front fender is a potato vine lifter adapted to Southern crops. The rear fenders are fabricated of sheet metal and are attached to the tractor just ahead of the rear wheels. The fenders are raised and lowered by the power lift of the tractor and operate when mounted in conjunction with the cultivator or when that implement is removed and either a sprayer or dusting unit installed.

At present, as far as cotton and some other crops are concerned, there is no complete answer to weed and grass control, except with a certain amount of hand labor. When it is realized that the production of an acre of cotton in the humid area has been accomplished with only $21\frac{1}{2}$ man hours and that this includes fourteen hours of hand labor in removing weeds, then the importance of the problem is clearly seen. No crop can be called completely mechanized until all hand labor is eliminated. To accomplish this goal means good farming and adequate "know-how", good machines adapted to them, precision and uniformity in all operations, coupled with the best in chemical, flame and mechanical weed control. No one method is sufficient, but a combination of all available control measures is indicated. More and more research will be necessary with the Engineer, the Chemist, the Agronomist and other research groups working as a team. Through close cooperation, the final answer will be found.

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[7] P. W. Gull, J. E. Adams and T. L. Baggette.

[8] J. K. Jones, Assistant Agricultural Engineer and Philip T. Hicks, Laboratory Mechanic

[9] E. Buford Williamson, Associate Agricultural Engineer; Warren R. Wortman, Laboratory General Mechanic; and Philip T. Hicks, Laboratory Mechanic.

Absorption of Radioactive 2,4-DI as Affected by Wetting Agents

John W. Mitchell[1] and Paul J. Linder[2]

Introduction

To be effective as herbicides, chemicals of the growth regulating type must be absorbed and translocated by the leaves and stems of plants. Knowledge about the absorption of these compounds and their movement in plants is important to those of us interested in weed control.

Some radioactive elements lend themselves very readily to the study of how and where these chemicals move in plants. This is true, first, because the method is very sensitive and extremely small amounts of the chemical can be detected. This is a definite advantage because only very small amounts of a substance such as 2,4-D is ever absorbed by the plant and a very sensitive method is needed to detect it. Secondly, with some radioactive substances, at least, the method is relatively simple and rapid in manipulation. Thus, with use of radioactive tracers, the absorption of a minute amount of the herbicide can be detected and its rate of movement within the plant measured accurately within a matter of a few hours.

The principle involved in the use of this method is not complicated. Radioactive iodine was used for the tracer studies described here. This isotope was selected because of its relatively slow rate of decay and the ease with which its radioactivity can be measured. A 2,4-D compound was then synthesized (6) in such a way that each molecule contained one atom of the iodine. The iodine was attached to the 2,4-D molecule in a known position, that is, it always occured in connection with the 5th carbon position on the phenyl ring part of the 2,4-D. For convenience this radioactive growth regulator is known as 2,4-D-5-I^{131} or just 2,4-DI^{131}. 2,4-DI^{131} can be prepared as the acid, an ester, or any one of a number of different salts. These radioactive compounds can now be purchased.

In using this material, the tagged acid form of 2,4-DI was dissolved in water or some other carrier and applied quantitatively to plants. Special applicators were used as a safety measure but the procedure is very simple and one measured drop (0.01 ml) can be quickly applied to the leaf or stem of a plant. When desirable, the growth regulator can be confined to a known area on the surface of the plant by first stamping a ring of lanolin on the leaf and then covering the enclosed area uniformly with the measured amount of mixture containing the 2,4-DI^{131}. Finally, to determine how much of the 2,4-DI^{131} has been absorbed, the plants were cut into parts, dried, ground, and the radioactivity in each sample measured. The amount of radioactivity detected is compared with that of a known standard and the amount of 2,4-DI^{131} in each plant part calculated.

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[1]Sr. Physiologist, [2]Physiologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S. Department of Agriculture, Beltsville, Maryland.

With such a method of detecting a chemical it is possible to study the effect of a number of factors on the amount absorbed and translocated within a plant. For instance, the relative amount absorbed by different parts of the plant under constant conditions can be measured, or the effect of adjuvants or of such factors as light and temperature can be readily determined.

Rate of Absorption 2,4-DI^{131} by Leaves

There is some evidence that 2,4-D does not move readily from the young rapidly developing leaves to other parts of a plant (3). In using tracers to measure the ability of leaves of different size to transmit a chemical, attached primary leaves of bean in 3 different stages of development were used. The test plants were illuminated by means of fluorescent tubes and grown under controlled temperature conditions. They were selected so that some had very young, newly unfolded leaves about 1.5 to 2 inches long, leaves of others were partially expanded (about 3/4 full size), while those of the remaining plants were fully expanded and considered to be mature. Ten micrograms of 2,4-DI^{131} were applied in the center on the upper surface of each leaf. Twenty-four hours later the amount of 2,4-DI^{131} translocated to the stems of plants in respective treatments was determined. The very young, rapidly expanding leaves failed to translocate an appreciable amount of the growth regulator, whereas leaves approaching full size moved more of the chemical than did the fully mature ones (table 1).

Table 1. Average absorption and translocation of 2,4-DI^{131} acid by primary leaves of bean at different stages of development.

Stage of development	2,4-DI^{131} applied (micrograms)	Average 2,4-DI^{131} per stem sample (milli-micrograms)
Slightly expanded	10	83
Moderately expanded	10	1052
Fully expanded, mature	10	674

Finally, the rate of absorption of 2,4-DI^{131} by leaves was measured during an extended period. A measured drop of 2,4-DI^{131} was placed on each leaf of a number of plants. The plants were then grown under constant conditions. Samples of the stems were collected at the end of each day following treatment for 4 days. The rate of absorption and translocation of the chemical from the leaves to the stems remained almost constant during the 4-day period (table 2).

Table 2. Accumulation of 2,4-DI^{131} acid in stems of bean plants with treated leaves.

Days after treatment	Average milli-micrograms 2,4-DI^{131} absorbed and translocated per day
1	390
2	410
3	500
4	340

Effect of Adjuvants on Absorption and Translocation of 2,4-DI^{131}

In using tracers to study the effect of co-solvents and detergents, eight different adjuvants were added to respective alicuots of a water solution of 2,4-DI^{131} acid. The influence of these adjuvants on the rate of absorption of the 2,4-DI^{131} was measured. Since some of these substances behave as spreading agents they were applied in 2 different ways: first, a measured amount of each mixture was spread over equal areas on leaves; second, the different mixtures were applied as single drops and these allowed to spread as far as they would over the leaf surface.

When the mixtures were confined to equal leaf areas, all of the adjuvants used significantly increased the absorption and translocation of the 2,4-DI^{131}. The increase ranged from 20 to 161 percent greater than the amount of growth regulator absorbed in water alone (table 3). These results indicate that the adjuvants increased absorption and translocation of the 2,4-DI^{131} irrespective of their spreading properties.

Table 3. Effect of co-solvents and surface active agents on the absorption and accumulation of 2,4-DI^{131} acid. Treatment confined to a surface area of 0.5 $cm.^2$ on each leaf.

Treatment	Percent increase over 2,4-DI^{131} applied alone*
Tween 20	161
Emulphor ELA	75
Carbowax 1500	69
Nekal-NS	63
Dreft	37
Repcolene	29
Igepal 300	22
BRIJ-30	20

*All increases significantly greater than the amount detected in control treated with 2,4-DI^{131} acid alone.

When the mixtures were applied and allowed to spread, however, the effect of the adjuvants on absorption of the 2,4-DI^{131} was increased by even a much greater amount - as much as 7 times that absorbed when the growth regulator was applied in water alone. It should be emphasized that this effect was obtained by adjuvants used with water containing the acid form of 2,4-DI^{131}. We have not yet measured the effect of these same adjuvants on the salt or ester forms of the 2,4-DI. On the basis of visual responses, some of these adjuvants are known to increase the rate of absorption of 2,4-D itself (1, 2, 4, 5).

The question arises as to why the addition of such substances as Tween 20 and Emulphor hasten the absorption and translocation of 2,4-DI. It is probable that these adjuvants may change the physical and possibly the chemical nature of the 2,4-DI mixtures in several ways, two of these effects have been detected and measured. First, all of the adjuvants used here have the property of reducing the surface tension of certain liquids and as a result the liquid containing the detergent spreads more readily when applied to a surface than when used without the adjuvant. In addition to this spreading effect, some of the adjuvants had a solublizing effect which likewise influenced absorption of the 2,4-DI^{131}. This solubilizing effect can be easily demonstrated by first dissolving a 2,4-D salt or the acid in water, then evaporating a drop of the water solution on a piece of glass. Crystals of 2,4-D appear as the water evaporates. But if a trace of Tween 20, for instance, is added to the water solution, then it is not possible to cause the 2,4-D to crystalize even if the glass is heated to drive off practically all of the water. The adjuvant serves as a solvent, keeping the 2,4-D finely divided and in close contact with the surface of the plant even in the absence of water. These two characteristics of the adjuvants used account in part for their effect of increasing the absorption of some forms of 2,4-DI^{131} and 2,4-D.

Distribution of 2,4-DI^{131} in plants when applied to their leaves

It was previously found that a radioactive growth regulator of a benzoic acid type accumulated mainly in the terminal buds of plants whose leaves had been treated with it. In the present experiments, the phenoxy compound, 2,4-DI^{131} acid, accumulated mainly in the upper stem of plants when tested in a way similar to that used in the case of the benzoic compounds (table 4).

Table 4. Distribution of 2,4-DI^{131} acid in bean plants following its absorption by their leaves.

Plant parts	Total amount per plant part (milli-micrograms)	Percent of total
Roots	134	4.1
Lower hypocotyl	299	9.2
Upper hypocotyl	1469	45.2
First internode	1165	35.9
Terminal bud	115	3.5
Petiole	66	2.1

This result is to be expected since most active compounds of the 2,4-D type affect the growth of succulent stems and also the growth of buds, while compounds of the benzoic acid type affect mainly the development of buds (7).

It is of interest to note that an average of 3,182 milli-micrograms of the 2,4-DI^{131} applied to leaves moved from the leaf blade through the petiole and accumulated in other parts of the plants. Only 2% of this total remained in the petiole itself. For some reason the growth regulating chemical failed to react with substances in the petiole tissues, but when the 2,4-DI^{131} reached the stem it readily reacted with substances there.

Summary

We have found (1) that very young as well as fully expanded leaves of bean may not absorb and translocate the growth regulating chemical, 2,4-DI^{131} acid, as readily as leaves that are partially expanded or that have recently become fully expanded, (2) that young but fully expanded leaves may absorb the 2,4-DI^{131} at a relatively constant rate provided that favorable conditions prevail; (3) that such adjuvants as Emulphor, Tween 20, and others may increase the rate of absorption of a growth regulator; and (4) that the 2,4-DI^{131} acid accumulated mainly in the upper stems of young test plants when the chemical was applied to their leaves.

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AN ANATOMICAL STUDY OF THE MODIFICATION OF BEAN LEAVES AS A RESULT OF TREATMENT WITH 2,4-D.[1]

Donald P. Watson[2]

The development of grotesque leaves on the bean plant, Phaseolus vulgaria, variety Red Kidney, becomes visible only after the first week following treatment with 2,4-D, when the young leaves that were in the bud at time of treatment have expanded. The purpose of this investigation was to learn the stages of leaf development that were vulnerable to the treatment, to locate these leaves in the bud, follow their development and locate them on the expanding plant, as well as to examine and describe their external and internal structure.

A series of eight groups of young plants was selected, each group with terminal bud lengths respectively of 4, 6, 8, 10, 12, 18, 24, and 36 mm. The plants were treated by injection into the midrib of one primary leaf 0.01 ml. of an aqueous solution containing 10 micrograms of 2,4-D and 0.5 percent carbowax 1500. The day following treatment, every plant exhibited severe curvature in the hypocotyl. After 28 days the plants were observed for type and severity of leaf injury. Using arbitrary categories for degrees of severity of injury, a system of classification consisting of five types of leaves based upon external characteristics of size, form, and structure was adopted.

Photographs and drawings are supplied to illustrate the types of leaf injury. It was shown that in modified leaves, the normal palisade and spongy mesophyll cells have been replaced with slightly thicker-walled cells that are well filled with water and contain few, if any chloroplasts. These cells are called "replacement cells". The quantity of tissue composed of replacement cells to a large extent determines the degree of severity of the injury and consequently the type of leaf injury. In general there is not as much replacement tissue in the leaves that are located above the most severely injured leaf as there is in those that are located below it.

Initiating regions in leaf development of the bean are located both terminally, and laterally. The effect produced by the application of 2,4-D, as it was used in these experiments, was found to be different for leaves in different stages of development at the time of treatment. In general, however, little, if any and probably no inhibition, took place in the initiating region itself. Affected leaves were reduced in size, and the amount of reduction was in direct relation to the severity of injury. This reduction in size was brought about by failure of the derivatives of the meristem to develop normally, resulting in a reduced lateral expansion of the interveinal parts of the blade and in consequent alterations in the normal leaf shape.

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[1] 2,4-D as used in this paper refers to recrystallized 2,4-Dichlorophenoxyacetic acid provided by Camp Detrick, Maryland. This paper is based upon the work done for Camp Detrick under contract No. W-18-035-CM-168 with Cornell University.

[2] Assistant Professor of Research, Department of Horticulture, Michigan State College; paper appears in full in the American Journal of Botany, Vol. 35, No. 9, 543-555, November, 1948.

In the less severly injured leaves, reduction in width is greatest at the base of the blade. These leaves are otherwise nearly normal in shape and structure. In the narrowed tapering bases, the veins are abnormally close together. This peculiar base owes its form to the fact that, as the lateral meristem builds up the young leaf blade, the meristem is oldest at the base and completes its function in this location first. When the effect of the treatment comes after the lateral meristem has activity, the derivatives of this meristem are at a vulnerable stage and normal lateral expansion of that part of the leaf fails to occur. In the younger part of the leaf, distal to the narrowed base, where the marginal meristem continues to function and its derivatives are not old enough to be affected, the leaf blade develops normally.

The apical meristem is apparently not affected by the stimulus and the young leaf continues to enlongate. The narrow enlongated leaf form is developed by the continuing activity of the apical meristem without normal activity of the lateral meristem. The central portion of the blade of these leaves is highly abnormal having failed to expand laterally. Commonly, a dark margin with closely packed chlorophyllous mesophyll which is not to any extent affected by the stimulus is developed by the marginal meristem after injured tissue toward the midrib has already been altered. Consequently, the dark margin is not found near the base of the leaf. There is a sharp line of demarkation between the dense marginal areas and the inner abnormal pale-green tissue. This seems to indicate a sudden termination of the effect of the stimulus. Since there is no lateral expansion of the inner portion of the blade, and the marginal meristem continues to increase in peripheral extent, as soon as its derivatives resume their normal development, this marginal strip assumes a much greater extent than the unexpanded blade to which it is attached. This results in the ruffled formation of the dard border. The smaller the young blade when the stimulus reaches the leaf, the more extreme the ruffling.

The modification of leaf form and structure is often very slight and can be interpreted in the light of an understanding of normal leaf development. The different stages display varying degrees of vulnerability to the stimulus that results from the treatment with 2,4-D. The great variety of form and structure found in the injured leaves is also readily interpreted on this basis.

When the plants with various bud sizes were treated with 2,4-D as described above, no serious change took place in the fully expanded leaves on any plants of the series. One week after treatment, when the terminal bud opened and the young leaves in that bud expanded, leaf injury became visible. On every plant the most severe leaf injury was found on a leaf that was still in the bud at time of treatment. After 28 days, ten shoots from each of the eight bud-sizes were examined to locate the position of the types of leaf injury.

In 4 and 6 mm. buds the first leaf is at a stage from which the same injury developes. In 8, 10, 12, 18, and 24 mm. buds this same leaf is at a stage where a less severe injury develops. Beyond this size in the 36 mm. bud stage, where the leaf at the time of treatment is expanding out of the bud, a normal leaf develops. A series of types of injury grading from that found in the first leaf to the most severe or normal is consistent for all plants studied. The location of the most severe injury is changed from leaf 2 in a 6 mm. bud at time of treatment to leaf 4 in a 36mm. bud. On the plants which had a 4 mm. bud at time of treatment the location of injury was sufficiently low on the stem to allow the fourth leaf to develop normally while at the other extreme, from 36 mm. bud, a normal leaf developed at the base of the stem, a leaf that had expanded sufficiently at the time of treatment to be uninjured by the stimulus.

Terminal buds were collected 0, 4, 6, 7 days following treatment from buds measuring 4, 6, 12, 24, 36 mm. in length at time of treatment. This material was examined in serial sections and the size and form of one leaf from one bud was representative of each type of injury at the four stages of development. Because of the consistency of the location of the type of injury among all intact plants of the same bud size, it was possible to relate each leaf in the bud, as it expanded over a seven-day period to the type of injury that eventually developed.

The size and form of leaves that eventually showed the same type of injury was closely similar. In a 4 mm. bud, a leaf that later developed into one type of injury was closely similar in size and form to another leaf in, for example, the 36 mm. bud that later developed into the same type of injury. This was true throughout the whole series. The most serious injury develops from a very small leaf yet one in which the lateral flanges are developed. Less severe injuries located higher on the stem develop from still younger stages, whereas those located lower on the stem develop from leaves that are fairly well developed at the time of treatment.

Since all leaves are normal that develop before or later than the normal leaf at each end of the series of injured leaves on the stem, it was desirable to locate in the bud the stage before and after which injury was negative. Any leaf that is sufficiently developed in the bud so that beginnings of marginal flanges have appeared at the time of treatment is vulnerable to the effect of the stimulus. No leaf that differentiates later, however, will be subject to injury.

Leaves that are old enough to be completely out of danger of the effect of the stimulus at time of treatment must be over 30 mm. in length from the place of attachment of the stipules at the base of the petiole to the tip of the central leaflet. A leaf of this size has extended beyond the bud proper and the leaflets are in the process of unfolding. The effect of the chemical is relatively rapid and does not injure leaves that have not yet begun to differentiate or leaves that have developed beyond a definite stage.

A normal leaf develops at the base of the stem of a treated plant when this leaf at the time of treatment has many elongated palisade cells, some elongation of the sub-palisade cells and the spongy mesophyll has not begun to separate to form intercellular spaces. In a few days intercellular spaces are well developed in the spongy parenchyma and slightly developed in the palisade cells, resulting in increase in lateral dimension of the leaf accompanied by increase in volume. When a leaf is at the right stage to be most vulnerable to the stimulus, the cells are arranged in a fairly well organized six-rowed condition. They are still isodiametric and well filled with cytoplasm. Within a few days, activity is rapid resulting is much cell division and the beginning of formation of replacement tissue, which is a departure from the normal course of cell formation. In the mature condition this leaf is filled with replacement tissue. The cells are greatly enlarged and have small or no intercellular spaces. The plastids are few and scattered. The leaf if thick and has not expanded laterally leaving the veins located close together. Types of leaf injury that show lesser degrees of severity result from leaves which at the time of treatment are either at a stage of development that is between the stage from which a normal leaf develops, and that from which a severe injury develops, or they are at a stage which is more advanced than the stage of greatest vulnerability.

Complete descriptions of the histological development of each type of injury is supplemented with photomicrographs of transverse sections of these leaves at the time of treatment, four and six days after treatment, and when mature.

(With 16 photographs, 4 diagrams, and 2 tables.)

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Drift and Volatility Comparison of an Amine Salt and Ester Form of 2,4-D Under Field Conditions

by: A.J.Tafuro[1], J.D.VanGeluwe[2], and L.E.Curtis[3]

Drift and volatility dangers from the use of various forms of 2,4-D are of particular importance in the northeast where crops sensitive to 2,4-D are often grown in close proximity to sprayed areas. On the basis of rather sensitive volatility tests in greenhouse, esters proved to be highly volatile in comparison to the salt formulations of 2,4-D (1). The different formulations of the salts and esters of 2,4-D will vary in volatility due to their individual chemical structure (2). This report concerns field testing of drift and volatility of an ester form and an amine salt form of 2,4-D.

Materials and Methods

A commercial formulation of triethanolamine salt of 2,4-D and a butyl ester of 2,4-D was used in this experiment. The work was done on the King Farms in Trumansburg, New York and materials were applied with a low pressure, low volume spray rig attached to a jeep. Two separate fields on different sections of the farm were chosen to avoid any contamination from drift or volatility of either material used. Each field was planted to field corn and both forms of 2,4-D were applied as a pre-emergence spray at the rate of 3/4-lb. acid equivalent per acre. Twelve rows in the middle of one field were sprayed with butyl ester and twelve rows of another field were sprayed with triethanolamine salt and each sprayed portion of the field consisting of approximately one acre. Tomato plants (Rutgers) which were all seeded at the same time, were potted in four inch pots when approximately 6 to 8 inches tall. These were used as indicators of drift or volatility of the two forms of 2,4-D in both fields. These potted plants were placed in identical positions and at the same time intervals in both fields at two different heights; one at ground level and the other two feet high. All tomato plants were kept out of the greenhouse for 24 hours prior to the experiment. To avoid any contamination of materials, the spraying was done by L.E.Curtis alone, while J.D.VanGeluwe and A.J.Tafuro handled all the plants and in no way were they in contact with the chemicals or the sprayer. The following Figure I will indicate more clearly the positions of the tomato plants to the sprayed portion of each field.

1,2,3, G.L.F. Soil Building Serv., Div. Coop. G.L.F.Exchange,Inc.

FIGURE I

W														E
	Brush						↑ N	Row						
	Station III						Sprayed 12 rows	Station VI						
	F	E	D	C	B	A	as a	A	B	C	D	E	F	
	192'	96'	48'	24'	12'	6'	pre-emergence	6'	12'	24'	48'	96'	192'	
							spray at 3/4-lb.							
W	←						acid equiv.						→	E
	Station II							Station V						
	F	E	D	C	B	A		A	B	C	D	E	F	
	192'	96'	48'	24'	12'	6'	↓	6'	12'	24'	48'	96'	192'	
	Brush						S	Row						

Figure I represents the position of the stations and locations of plants in relation to the sprayed portion of the two fields. Both fields were sprayed on June 12th, 1949

Before either field was sprayed two tomato plants were placed at each height at the A, B, C locations while one plant was placed at the high level of D, E, and F. The reason for the difference was to measure actual spray drift as compared to immediate volatility. Only stations II and III were used for this setting since the wind was blowing from East to West. Immediately after spraying one set of plants from both levels was removed from location A, B, and C of each station. One-half hour after spraying, all remaining plants were taken from these locations and a new set of indicator plants were placed at all locations of stations II, III, V and VI. This setting was kept in the field for 24 hours, then removed. Another group of plants replaced these in the field and were also kept in the field for a 24 hour period. All the tomato plants were kept outdoors and watered daily until injury readings were completed. The first recordings were made ten days after the last plants were removed from the field and a second recording made five days later. Each potted plant was given a series of code numbers for identification when injury recordings were taken. Table I records type of injury to each individual plant at the different stations, location and time interval. All data in Table I represents the last readings, taken fifteen days after the test was completed.

TABLE I

Time Interval	Material	Plant Settings	Location A - 6'				Location B - 12'				Location C - 24'				Location D - 48'				Location E - 96'				Location F - 192'			
			Stations				Stations				Stations				Stations				Stations				Stations			
			II	III	V	VI	II	III	V	VI	II	III	V	VI	II	III	V	VI	II	III	V	VI	II	III	V	VI
1	A	H	S	L			M	S			S	L			X	X										
		L	S	S			S	X			M	S														
	E	H	S	S			S	S			S	M			S	S										
		L	S	M			M	S			S	S														
2	A	H	S	L			S	L			M	L			M	L			X	X			X	X		
		L	S	X			S	X			L	L														
	E	H	S	L			M	M			M	S			M	L			L	M			L	X		
		L	S	S			M	M			S	L														
3	A	H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		L	X	X	X	X	X	X	X	X	X	X	X	X												
	E	H	L	M	S	L	L	M	M	M	M	D	S	M	M	L	S	X	D	S	S	S	X	L	B	L
		L	B	X	L	S	L	S	M	M	D	L	X	S												
4	A	H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		L	X	X	X	X	X	X	X	X	X	X	X	X												
	E	H	S	L	S	S	S	D	S	M	S	M	B	M	S	S	S	S	L	M	M	M	S	S	B	B
		L	L	S	S	M	L	L	B	B	M	S	S	S												

1-Plants set before spraying & removed immediately after spraying.
2-Plants set before spraying & removed $\frac{1}{2}$ hr. after spraying.
3-Plants set $\frac{1}{2}$ hr after spraying & removed 24 hours later.
4-Plants set 24 hours after spraying & removed 24 hrs.later.

D - Dead
M - Moderate
S - Severe
X - No injury
B - Broken
L - Slight

H - Tomato plant placed on 2' high stand
L - Ground level

A - Amine
E - Esters

Stations II and III - West side of field
Stations V and VI - East side of field

Discussion

In this experiment the air temperatures at ground level for a 48 hour period reached a daytime high of 97°F. and an evening low of 64°F. Air temperatures were obtained by a recording thermometer in the field. Wind velocity recorded in feet per minute at time of spray was 4 to 6 miles per hour in gusts from the northeast changing to southeast winds in the evening. The second day of the readings, winds were 5 to 7 miles per hour from the southeast. Sprays were applied to each field $1\frac{1}{2}$ hours apart starting at noon on June 12, 1949.

Epinasty readings of indicator plants at time interval #1 (before spraying and removed immediately after spraying) indicate abnormalities to tomato plants in the amine field at 24 feet as compared to 48 feet in the ester field, whereas on interval #2 (before spraying and removed $\frac{1}{2}$ hour after spraying, epinasty was observed at 48 feet by amine as compared to 192 feet with butyl ester. Tomato plants placed in the field $\frac{1}{2}$ hour and 24 hours after spray (#3, #4 time intervals respectively) developed epinasty in the butyl ester field at all locations up to 192 feet, whereas no plants in the amine field produced any abnormalities at either of these time interval settings. Both settings were kept on the field for a 24 hour period.

Plants removed from the sprayed field immediately and $\frac{1}{2}$ hour later (#1 and #2 time intervals respectively) could have developed epinasty from spray drift or immediate volatilization or both, since both plant settings were in the field at the time the spray was applied. In both cases the butyl ester formulation developed epinasty at further distances.

Summary

The results of this test under field conditions, follows somewhat closely the results observed in greenhouse work (1), with the two different formulations of 2,4-D used in this experiment.

Although indicator plants were not placed far enough to go beyond where epinasty was produced in the case of the butyl ester formulation of 2,4-D field, it appears that spray drift (time interval #1) is more serious with the butyl ester as compared to the triethanolamine salt formulation of 2,4-D.

Immediate spray drift or volatilization, or both, of the butyl ester formulation of 2,4-D caused epinasty to indicator plants at a further distance from the sprayed field when compared to the triethanolamine salt formulation of 2,4-D (time interval #2).

With plants placed in the field one-half hour and 24 hours after the spray was applied and left in the field for a 24-hour period (time interval #3 and #4 respectively), it is evident that epinasty produced by the butyl ester formulation of 2,4-D was caused by volatilization under field conditions

No epinasty of the indicator plants occurred from volatility one-half hour or thereafter in the case of the triethanolamine salt formulation of 2,4-D at the closest point (six feet) to the sprayed field (time interval #4).

Epinasty of the indicator plants occurred from volatility in the case of the butyl ester formulation at the farthest point (192 feet) that the indicator plants were placed at the longest time interval (24 hours) after the spray was applied. (time interval #4)

Conclusions

With wind velocities of 5 to 7 miles per hour the triethanolamine salt of 2,4-D is less hazardous to use than the butyl ester formulation where drift or volatilization may endanger nearby crops susceptible to 2,4-D.

Where injury to nearby susceptible crops is a problem, the use of a volatile ester such as the butyl ester formulation of 2,4-D is hazardous at least up to 192 feet from the sprayed bare field (pre-emergence) which was the farthest point indicator plants were placed.

Volatilization danger should be tested at greater distances and for longer periods from the sprayed bare field as well as the possibility of even greater volatilization from a volatile ester sprayed on weeds and crops.

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THE APPLICATION OF HERBICIDAL SPRAYS TO FIELD PLOTS AND THEIR EVALUATION

by
W. B. Ennis, Jr. and A. G. Norman[1]

Frequently in development work on selective herbicides possible effects on particular crop plants must be determined with accuracy. Moreover in the evaluation of new compounds and formulations applications may have to be made at sub-lethal levels or sub-effective levels in order that small differences can be detected. In such studies it is particularly important that the treatment be applied in a uniform and unbiased manner. While this was not so difficult when high volume spraying was practiced, it is of great importance now that low-volume sprays have become widely adopted.

This paper cites examples in our experience of the difficulty of carrying out wholly unbiased reproducible field-plot work.

1948 Experiment

In 1948 a special statistical study of the yield data of one field experiment was made to determine whether there had been bias in applying various spray treatments. The experiment was of randomized complete block design and had previously been designed for testing the effect of volume of spray upon the herbicidal qualities of a growth-regulating substance on soybeans. Each plot consisted of 3 rows 18 ft. long. The same threshold amount of the compound dissolved in 1 percent Tween-20 aqueous solution was applied in quadruplicate at rates of 1, 5 and 10 ml. per sq. yd. when the plants were 23-27 inches tall (blossoming stage). A modified DeVilbiss MBC spray gun fitted with MBC-231 combination spray head and veiling cap was used in applying the solutions. The gun was operated under 10 lbs. per sq. in. air pressure and the fluid adjustment screw was set to deliver slowly and completely the desired volume of liquid as fine droplets. The plot was covered 2 or 3 times as uniformly as possible. To prevent drift of spray, a movable chamber, having a light metal frame and covered with a wind-resistant cloth, was used around the plot. The chamber was five feet in height and could be telescoped to fit various size plots. Normally one end of the chamber leeward to the wind was left open to facilitate spraying. By placing a top on the chamber operations could be carried out in winds of 10 m.p.h. without danger of drift.

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[1]Agronomist and Biochemist, respectively, Biological Department, Chemical Corps, Camp Detrick, Frederick, Maryland.

In this particular experiment the sprays were applied according to a prescribed pattern. The operator moved from the open end of the spray chamber toward the other end of the plot applying the spray to the three rows by moving the spray gun from left to right over the plants in a steady, rhythmical fashion. The operator faced toward the rear of the spray chamber as he moved up and down the rows of the plot.

The three rows in a plot were arbitrarily termed a, b, and c with the b row being the center row in each plot. At harvest it was assumed that if row a in the various plots was treated consistently with a heavier spray than row b or c then this differential treatment would be reflected in the yield of the plants in these rows. Accordingly, the center rod portion of each of the three rows in a plot was harvested separately and its identity was kept throughout the drying, threshing, and weighing processes.

The data were analyzed to determine the effect of position of one row in a plot with respect to another (row effect). Analysis of variance (table 1) indicates that there were highly significant differences among rows and that this difference follows the same pattern within each treatment. For example, if we let the letters A, B and C represent the yields of rows a, b, and c, respectively, then in each treatment usually A is greater than B which is greater than C. This feature may be due to a soil gradient or to a bias in spraying or to both. Since row c was always to the right of the operator applying the spray, it is possible that there was enough bias in the spraying technique to account for row c yielding uniformly less than row a or b. The differences in yield between the untreated plots were of a random nature and did not suggest a soil gradient. Thus, by statistical treatment of the yield data from each of the 3 rows in a plot it was shown that there was a highly significant row effect; undoubtedly the operator was biased to the extent that he tended to spray the row to his right more heavily than the other 2 rows in a plot.

TABLE 1

Analysis of variance (omitting control) of data from 1948 spray experiment for "row" effect

Source	d.f.	Mean Square	F
Whole plot			
Rep	3	10,185	
Treat	5	39,490	**
Error a	15	879	
Sub-plot			
Row	2	16,204	9.48**
Row x Treatment	10	1,710	n.s.
Error b	36	1,071	
Total	71		

It is also to be noted in table 1 that the mean square value for rows is larger than that for replicates; this indicates that in the experiment row effect was more important than variation in soil fertility.

Additionally, analysis of variance of the individual sets of row data, i. e. row a, row b, and row c, and rows a+b+c, were also calculated in order to determine the error variance, standard deviation and coefficient of variability (table 2). Before the data from all three rows were combined Bartlett's test for homogeneity of data (Snedecor's Statistical Methods, p. 250) was made; the value of Chi square was far below the 5% level of probability, hence the data were homogeneous and could be combined for analysis purposes.

The calculation of the coefficient of variation for yields from the center row (b), left row (a), right row (c) and rows a+b+c revealed that least variation occurred when all 3 rows of a plot were harvested and the yields combined (table 2). This indicated that greater precision was achieved by harvesting 3 rows than by harvesting a single row. The data also suggested that the center row was the best single row in a plot to harvest.

TABLE 2

Summary of statistical tests for variability of data from 1948 spray experiment

Row No.	Error Variance	$\bar{X}$ for all plots	S. D. of adjusted mean* (S.D. = $\sqrt{\text{error var.}}$)	Coefficient of variation
a	1249	298.0	35.3	11.84
b	863	272.4	29.4	10.78
c	1156	251.5	34.0	13.52
a+b+c	2996	821.9	54.7	6.66

* Treatment and replication variation controlled

1949 Experiments

The results obtained from the 1948 field experiment on soybeans implied that in future experiments the operator should cover the plot in such a way that there would be no bias in treating the various rows in a plot. In addition the results indicated that when small differences between treatments are expected more than one row should be harvested, because of the increased precision over a single row.

In an attempt to eliminate or reduce the bias in spraying which occurred in the 1948 experiment, a different spraying technique was adopted for two split-plot soybean experiments in 1949. The operator used the same spray gun as in 1948 but instead of spraying the plots so that he faced in one direction only, the operator reversed the direction he faced as he reached each end of the plot. Consequently, there should have been equal compensation for any tendency the operator may have had to spray plants on his right more heavily than on his left and vice versa.

Experiment I was designed to study the influence of different carriers upon the herbicidal action of a growth-regulating substance upon soybeans. Threshold amounts of the compound in the different carriers were applied in quadruplicate at a volume rate of 3 ml. per sq. yd. Plants were 30-36 inches tall (late flowering) when treated.

Experiment II was set up to test the effect of volume of spray upon the herbicidal action of a growth-regulator applied in three different carriers. Threshold amounts of the compound were applied in volumes of 1, 2.5 and 5 ml. per sq. yd. of the different carriers. All treatments were made in quadruplicate to plants 28-34 inches tall (late flowering).

Yield data were taken on the individual rows in a plot as in 1948. The data were analyzed in the same way as those in the 1948 experiment (tables 3, 4, 5, 6).

Although analyses of 1948 data indicated that there was a highly significant row effect, undoubtedly due to bias in spraying, the attempt to overcome this in the 1949 experiments was not fully successful (tables 3, 5); the operator tended to spray the center row more heavily than the row to the right or left.

The results obtained from statistical analyses of the two split-plot experiments in 1949 substantiated the results obtained in 1948; the coefficient of variation of the combined yields of rows a+b+c was lower than for any single row. Likewise, the coefficient of variation for the center row of the plots was slightly lower than for row a or row c which indicated that the center row was probably the best single row to harvest.

TABLE 3

Analysis of variance (omitting control) of data from 1949 spray experiment I for "row" effect

Source	d.f.	Mean Square	F
Rate	1	344,541	**
Replicates	3	1,175	n.s.
Error a	3	624	
Treatment	4	144,882	**
Treatment x Rate	4	8,536	**
Error b	24	1,173	
Row	2	11,746	6.8**
Row x Treatment	8	2,651	n.s.
Row x Rate	2	766	n.s.
Row x Treatment x Rate	8	725	n.s.
Error c	60	1,726	
Total	119		

TABLE 4

Summary of statistical tests for variability of data from 1949 spray experiment I (control omitted)

Row No.	Error Variance	$\bar{X}$ for all plots	S. D. of adjusted mean* (S.D. = $\sqrt{\text{error var.}}$)	Coefficient of variation
a	1611	277.6	40.14	14.46
b	992	243.6	31.49	12.93
c	1735	257.2	41.65	16.19
a+b+c	1112	778.4	33.34	4.28

* Treatment and replication variation controlled

TABLE 5

Analysis of variance (omitting control) of data from 1949 spray experiment II for "row" effect

Source	d.f.	Mean Square	F
Rate	1	641,247.1	**
Replicates	3	6,989.2	n.s.
Error a	3	6,952.8	
Treatment[1]	8	439,285.1	**
Treatment x Rate	8	11,560.5	n.s.
Error b	48	2,642.0	
Row	2	8,692.0	5.96**
Row x Rate	2	268.6	n.s.
Row x Treatment	16	1,653.7	n.s.
Row x Treatment x Rate	16	631.5	n.s.
Error c	108	1,458.7	
Total	215		

[1] Treatment consisted of 3 different carriers applied at 3 volume rates; volume and carrier effects have been combined for simplification.

TABLE 6

Summary of statistical tests for variability of data from 1949 spray experiment II (control omitted)

Row No.	Error Variance	$\bar{X}$ for all plots	S. D. of adjusted mean* (S.D. = $\sqrt{\text{error var.}}$)	Coefficient of variation
a	2136.8	343.3	46.22	13.46
b	1703.9	341.5	41.27	12.08
c	1913.6	361.4	43.74	12.10
a+b+c	2895.6	1046.2	53.81	5.14

* Treatment and replication variation controlled

DISCUSSION

Statistical studies of the yield data from three field-plot experiments involving spray applications of plant growth-regulators to soybeans indicated that in spite of the great care exercised in making the treatments, the operator was biased in applying the sprays. Indeed, these results imply that if workers are not extremely careful the bias in applying low-volume sprays to field-plots may be serious. The significant row effect, attributable to bias introduced by the operator, in these particular experiments did not obscure the main comparisons between the different carriers, volumes and rates. However, in some instances bias in applying sprays might lead to wholly erroneous conclusions. For example, if a worker is attempting to establish critical acre rates for selectively controlling weeds in a crop, such as flax, and if the spray is applied in a biased manner, then the recommendations developed may be too high or too low according to his selection of subplot sample for harvest and yield determination.

Additionally, the statistical studies of these experiments showed that the variation caused by biased spraying of the plots was partially overcome by harvesting the whole plot (3 rows) rather than a single row; thereby greater precision was achieved at the expense of the additional labor in harvesting and threshing. By attaining greater precision in experiments the significance of small differences between treatments can be determined more accurately than in less precise experiments. It should be pointed out that a large source of experimental error in each of these experiments was attributable to lack of uniformity in spraying the plots rather than to soil heterogeneity, genetic variations, etc. Actually, the error would not have been reduced in these experiments by increasing the number of replicates of treatments.

A survey of the information published in the proceedings of the several weed control conferences reveals that the details of experiments are often incompletely reported; undoubtedly, this is due in part to the fact that such reports must necessarily be brief. Nevertheless, for critical comparisons of the results obtained by workers in different locations and in different years it is important not only to consider the environmental influences but also the exactitude with which the experiments were carried out. Too frequently no mention is made of the particular experimental design, method of applying the sprays, the care exercised in applying the treatments to avoid bias, physical characteristics of the spray, method of evaluating results, etc.

Herbicidal investigations have now assumed an important role in agricultural research. Perhaps the time is ripe to take stock of experimental methods with a view to improvement. The experiments herein reported revealed shortcomings in procedures which superficially were not obvious. If such bias could be eliminated the gain in precision would be a significant advance in herbicidal experimentation.

PROGRESS IN THE HERBICIDAL APPLICATION OF OILS

BY

H. L. YOWELL

ESSO LABORATORIES -- STANDARD OIL DEVELOPMENT CO.

Petroleum is an extremely complex mixture of thousands of hydrocarbon compounds which, when individually sprayed on vegetable foliage, exhibit only one property in common; namely, a rapid and uniform wetting of all plant life. The visible physiological response of vegetation to this sudden and complete wetting with individual hydrocarbons varies from rapid and complete death to no perceptible permanent ill effects(1). This remarkable ability of a wide variety of weeds and crops to respond physiologically in such variant ways to different individual hydrocarbons is already leading to a number of selective weed control methods based on petroleum. Fortunately, growing plants appear unable to distinguish between close members of a hydrocarbon homologous series. Since present refinery techniques can conveniently separate petroleum products into narrow boiling fractions of the same type hydrocarbons, weed control methods based on such products appear economically feasible. Several of these new developments are discussed in detail in later papers at this Conference and the present report represents an attempt to present a general review of the recent progress in petroleum weed control developments.

A. Petroleum Products as Contact Herbicides

Although methods for selectively deweeding crops are more impressive and glamorous, the need for potent contact herbicides is too great to abandon research on them at the present time. One important use for contact herbicides is in pre-emergence weed control which, though as yet not widely practiced in the Northeastern states, is still destined for wide scale usage sooner or later. Many petroleum products such as heating oil and Stoddard Solvents function satisfactorily as pre-emergence herbicides, but at application rates of less than 80 gallons per acre the effectiveness of these materials becomes less certain. By far the most attractive petroleum pre-emergence herbicides are the high aromatic concentrates in the kerosene and heating oil boiling range. Excellent pre-emergence weed control can be realized with these products at application rates of only 30 gallons of oil per acre when the delayed planting technique is employed. This quantity of oil gives equal weed control when applied either directly with low gallonage nozzles or as an aqueous emulsion in conventional spray equipment. One important factor to be kept in mind when using pre-emergence weed control applications of aromatic oils is that the residual effect rarely persists longer than 3 to 4 days after spraying. This rapid dissipation of toxic residues is somewhat disadvantageous in some instances when weed seeds are slow in germinating, but from the standpoint of injury to a sensitive crop, the aromatic oils are undoubtedly the safest and most fool-proof of the pre-emergence herbicides presently employed.

The unique plant wetting properties of petroleum make them powerful activators for practically all of the chemical contact herbicides. This has been recognized for years and substantially all of the dinitro phenolic herbicides are either marketed in oil solutions or carry recommendations that oils be added to them prior to application. When used in combination with chemicals the aromatic content of the petroleum products appears to have little or no influence on the weed killing activity of the resultant herbicidal composition. Pentachlorophenol and its sodium salt are also only a few of the many other chemical herbicides greatly activated by oil. The addition of oil to these contact chemical herbicides is especially advantageous since it markedly reduces the quantity of chemical required to give adequate weed control and thus lessens the possibility of permanent soil sterility.

Herbicidal oils are particularly effective against grasses and consequently make excellent adjuvants to many of the chemical weed killers that are not particularly effective against annual and perennial grasses[2]. Extensive experiments conducted by Dr. Ora Smith of Cornell and his students at the Inter-American Institute of Agricultural Sciences in Costa Rica have shown that the grass killing properties of petroleum products have made them especially valuable in herbicidal formulations for weed control in tropical crops where grasses are particularly troublesome.

B. Petroleum in Selective Weed Control Applications

1. Selective Weed Control with Blanket Applications of Stoddard Solvents

The early work in California showing that stove oil could be used as a selective herbicide for deweeding carrots and the independent discoveries of Professor R. D. Sweet in New York[3] and Professor W. H. Lachman in Massachusetts[4] that Stoddard Solvents are the preferred oils for this purpose have been largely responsible for the tremendous amount of research on the herbicidal applications of petroleum. To date, no other crop has shown such a remarkable tolerance to a deluge of a herbicidal petroleum product as carrots. Parsley, parsnips, and celery seedlings (before transplanting) are sufficiently immune to the Stoddard Solvent sprays that satisfactory selective weed control can be obtained when competently applied.

Conifer seedlings also are somewhat resistant to blanket applications of Stoddard Solvents and where suitable precautions are observed, excellent selective weed control is realized. Stoddard Solvents have been successfully used as selective herbicides in large forest nurseries by Eliason[5] in New York and Cossitt[6] in Georgia, both having intensively investigated this weed control method.

Recent work by Cross[7] in Massachusetts and other workers in New Jersey and Wisconsin has shown that cranberry vines, when sprayed in the dormant state immediately after the bogs are drained in the spring, show a tolerance to high application rates of both kerosene and Stoddard Solvents which permits their use as effective selective herbicides. The time of application is critical in this instance since actively growing cranberry vines are severely injured or killed by Stoddard Solvents.

2. <u>Selective Weed Control by Directional Applications of Stoddard Solvents</u>

One of the more recent and destined to be one of the most important contributions to the selective weed control potentialities of petroleum was made by Messrs. W. E. Meek and O. B. Wooten of the Agricultural Engineering Department at the Delta (Miss.) Experiment Station. They discovered that a herbicidal oil normally lethal to cotton when applied as a conventional blanket spray could be used as a selective deweeding agent in this crop by introducing a new departure in the method of spray application. This new technique involves directing the oil spray at the very base of the cotton plant by means of a new type of spray equipment designed by them which prevents the herbicide from contacting the cotton stalks over one inch above ground level. Subsequent intensive research carried out by Dr. P. J. Talley at the Delta Station has shown that Stoddard Solvent type petroleum products are the preferred herbicides in this new development. Gallonage rates applied in this weed control method, when calculated on the basis of the amount of oil sprayed on the drill row, are in the range of 20 to 40 gallons per acre. Since the Stoddard Solvents do not leave a toxic residue to kill later crops of weeds, several treatments are required during a long growing season.

Work this summer at Cornell by Sweet and Dallyn, with equipment based on the Delta Station's design, indicates that a number of vegetable crops may be selectively weeded by this new technique. Considerable research effort is presently in progress at several locations to ascertain the full potentiality of this agricultural engineering development which has opened a new vista for the application of petroleum as a selective herbicide.

3. Selective Weed Control with Other Petroleum Products

One crop showing an amazing resistance even to the most potent herbicidal aromatic sprays is sugar cane. Early work by Hance[8] in Hawaii showed that oil emulsions of pentachlorophenol and/or its sodium salt could be used as a selective herbicide in sugar provided the spray contacted only the lower portions of the cane stalks. Although the outer sheaths were killed by this treatment, the inner sheaths and the sugar cane plant suffered no visible injury. Crafts[9] was able to show that 2,4-D could be included in this mixture, provided the time of application was carefully observed. At the present time extensive field tests underway at the Louisiana Station are showing promise for directional sprays of aromatic oils (with and without added pentachlorophenol) as selective herbicides for killing Johnson grass seedlings in sugar cane. Preliminary experiments at the Louisiana and Delta (Miss.) Experiment Stations also show that even young cotton is tolerant of aromatic oils provided application is made while the stalks still have a waxy coating.

3. Selective Crab Grass Eradicants

Grigsby[10] has reported that certain volatile petroleum fractions showed some promise as selective crab grass eradicants in lawn turfs. Work is also in progress at Rhode Island State College and Rutgers University on the use of oils and oil emulsions for this purpose. Promising leads are evolving from the work at these two stations, but no sure-fire "lawn oils" comparable to "carrot oils" have yet been developed.

4. Conditions Under Which Oils have been Used as Selective Herbicides

An analysis of the preceding information shows that petroleum fractions have been successfully used as selective herbicides on several crops by:

(a) Finding crops that are uninjured by a blanket spray application of a selected petroleum herbicide; e.g., Stoddard Solvents for carrots.

(b) Finding a time of the year when a blanket spray of a normally lethal herbicide is relatively non-injurious to a crop; e.g., Stoddard Solvents and kerosene for cranberries.

(c) Devising novel methods of applying a normally lethal herbicide to a crop without causing injury. In the examples cited below the new technique of herbicidal application proved successful because the stems of living plants are as selective in response to petroleum fractions as their foliage and do not necessarily respond in an identical manner; e.g., Stoddard Solvent type products as low-gallonage directional sprays for cotton.

(d) A combination of items (b) and (c); e.g., aromatic oils in sugar cane and young cotton.

On the basis of the selective weed control methods developed with petroleum herbicides to date, Stoddard Solvent is the one product that has dominated the field. Apparently this fraction which is of intermediate herbicidal activity, is on the borderline of toxicity level that can be tolerated by a few crops and still be lethal to a large number of weed varities. Consequently, whenever the possibility of a selective oil herbicide is indicated, Stoddard Solvent should definitely be one of the first petroleum products selected for trial. However, the fact that some plants such as sugar cane and young cotton can withstand the lethal effects of the more potent aromatic hydrocarbons leads one to predict that even the most toxic petroleum products will be developed into useful herbicides in the near future.

C. Petroleum Products as Activators for 2,4-D

The remarkable effectiveness with which 2,4-D can be used as a herbicide often tends to lead us to a feeling of complacency in the use of this miraculous compound. However, in view of the information available at the present time it would appear that applications of 2,4-D in the absence of an oil carrier or oil activator have not utilized this herbicide at its maximum efficiency.

Timmons[11] reported that in the airplane application of 2,4-D to control weeds in wheat, one-third pound of 2,4-D as ester in one gallon of diesel oil per acre gave more efficient weed control than two-thirds pound when applied in 5 gallons of water, while the latter quantity of 2,4-D in only 2 gallons of water proved inadequate as an effective herbicidal treatment. This remarkable increased coverage and more efficient utilization of the 2,4-D, when applied as an oil solution, results from the excellent plant-wetting and penetration properties of oils. The diesel oils also have much lower evaporation rates than water and thus significantly reduce volatilization losses of the 2,4-D components.

Burge[12] has found that the emulsification of either Diesel oil or preferably a summer spray oil at the rate of 1 quart per pound of 2,4-D greatly improves its weed control efficiency in high gallonage sprays. Experimental work at several experiment stations has indicated that either horticultural oils or diesel oils are equal in effectiveness as promoters and/or carriers for 2,4-D but that the latter sometimes produces slight burning of the economic crop. The remarkable effectiveness of oils as carriers to obtain maximum coverage and penetration of the systemic poisons 2,4-D and 2,4,5-T into woody plants has been recognized for some time and thousands of acres of utility right-of-ways were treated with this composition during 1949.

Professor Ora Smith and coworkers have observed in repeated experiments carried out in Costa Rica that the addition of 5 gallons of diesel oil to each pound of 2,4-D applied as a pre-emergence herbicide in corn, increased the duration of weed control from 2 to 3 weeks over similar treatments made in the absence of oil. This is apparently one of the first reports of this unexpected and not readily explainable property of the 2,4-D in oil herbicidal mixtures.

D. Petroleum in Aquatic Weed Control Applications

One of the most pernicious weeds from the standpoint of the maintenance of drainage ditches and navigation channels in the Southeastern United States is the water hyacinth. Fortunately its destruction in the principal canals of Florida has been most efficiently effected by airplane applications of 2,4-D in oil[13]. On the other hand, submerged weeds have been building up to prohibitive levels following the eradication of the surface hyacinths and this problem is now quite critical in Florida. Emulsified aromatic naphthas in concentrations of 200 to 300 PPM are showing considerable promise as eradicants in these tests. Earlier work by Moran and Shaw[14] had shown these materials to be quite efficient for killing weeds that were choking irrigation ditches. The desirability of the light aromatic naphthas in this particular instance was that after the emulsions broke, the oils floated on top of the water and rapidly evaporated leaving no toxic residues to damage the irrigated crops.

E. Liquified Petroleum Gases as Fuels for Flame Weeders

Although previous sections of this paper have been concerned with the utilization of the herbicidal properties of refinery fractions per se, the widespread usage of flame cultivators for selectively deweeding cotton and sugar cane deserves some mention. From the standpoint of compactness of flame applicators, the liquified petroleum gases (propane and/or butane) are the preferred fuel. Significant advances in burner design have recently evolved from the cooperative program of the U.S.D.A. Cotton Mechanization Program which provides for greatly improved control of the flame patterns. These new developments, to be discussed by Mr. Meek in a later paper, have greatly improved the safety and effectiveness with which flames can be used in cotton and should make them applicable as selective deweeding agents in other crops that have been severely injured by the flames from earlier designed burners.

In conclusion, it should be emphasized that no attempt has been made in this report to cover the literature of petroleum herbicides completely. The topics discussed above were merely selected to summarize the more recent significant developments in the use of petroleum in weed killing applications with the thought that some of these new techniques might be of value in the solution of the many weed control problems confronting the members of this conference.

Petroleum, in all its complexity, is indeed a source of a tremendous number of products that are proving most valuable for weed control purposes. In the light of present information it would appear that the early anonymous statement "Eventually more oil will be sprayed on the ground as weed killers than is burned in farm tractors" is not without justification.

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A New Group of Defoliant-Herbicidal Chemicals[1,2]

Nathaniel Tischler,[3] James C. Bates,[4] Gorgonio P. Quimba[3]

Introduction

During the course of developing new plant response chemicals as part of a general program of research on various kinds of agricultural chemicals at the laboratories of Sharples Chemicals Inc., it was discovered that the 3,6-endoxohydrophthalic acids and their salts have unusually interesting plant response properties. For example, the primary leaves (second nodal leaves) of young bean plants, with undeveloped trifoliate shoots, would defoliate when treated with 3,6-endoxotetrahydrophthalic anhydride (hereafter designated as 3321) in aqueous solutions. It has been shown that a number of functional and structural relatives of 3,6-endoxotetrahydrophthalic acid possess considerable defoliant activity against a fairly wide variety of plants, including cotton, lima and string beans, soybeans, holly, hydrangeas, apple, peach and certain evergreens.

The chemical also possesses outstanding herbicidal activity. The chemical falls into the class of defoliant-herbicides, i.e., that it can be used both as a defoliant and as an herbicide, depending on the species and maturity of plants and in accordance with the dosage. For some particular plant species and for particular plant states, including maturity, there is an optimum range of amounts of chemical which induces defoliation. When this optimum range is considerably exceeded, phytotoxic effects become manifest.

Various related compounds, including 3,6-endoxohexahydrophthalic acid and a large number of its salts, also possess defoliant-herbicidal properties equally as marked as the unsaturated anhydride (3321), its acid, and its salts. Thus the 3,6-endoxohydrophthalic acids and their derivatives as a group are unusually effective as defoliants and herbicides. In the present paper, reports on various phases of the work with the 3,6-endoxohydrophthalic acids and several of their salts as defoliants and herbicides will be presented, giving data from typical applications.

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(1) Contribution No. 226, Department of Horticulture, Kansas State College. Cooperating Investigation, Kansas Agricultural Experiment Station and Sharples Chemicals Inc.

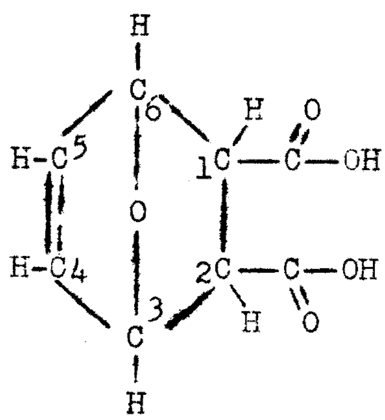
(2) All references to the literature are symbolized by small letters; the literature is given at the end of the paper.

(3) Biologists, Sharples Chemicals Inc.

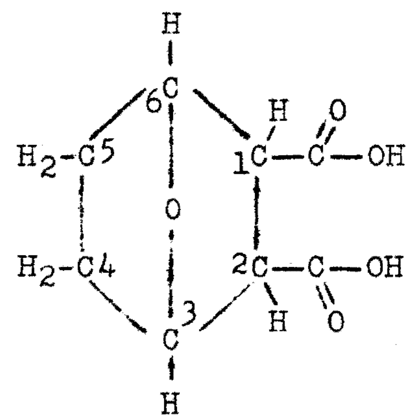
(4) Associate Professor of Horticulture, Kansas State College, Manhattan, Kansas.

Chemistry of Compounds

The two formulas below show 3321-A, the free acid of 3321, and 3441, the 3,6-endoxohexahydrophthalic acid.



3321-A



3441

A very large number of salts of both of these acids have been prepared. These include the neutral alkylammonium, alkanolammonium, ammonium, sodium, potassium, and various other metal salts. Many of the acidic salts, those in which only one of the carboxyl groups has been neutralized, have also been prepared. The plant responses of a relatively large number of salts has led to the conclusion that the anion is the active portion of the molecule. Although the particular salt employed may greatly influence physical properties, such as, ease of handling, and similar characteristics, they are not significant so far as the effects on the plant are concerned once the anion has become available to the plant tissues. With this in mind this paper, for the purpose of brevity, will be limited to typical applications with only a few of the salts. Five compounds will be specifically dealt with, namely, the anhydride (3321) and the free acid (3321-A) of the unsaturated form, the saturated acid (3441), the disodium salt of 3441[5] (namely, 3504), and the bis-triethylamine salt of 3441 (namely, 3739). Of the two different classes of anions it should be noted that the 3321-type anions are somewhat less stable than the 3441-type anions.

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(5) In an addendum to an article, "Improved Methods on Defoliation of Cotton", by H. C. Guy, Chemurgic Papers, No. 12, 1949 series, the editors reported that Sharples Chemicals Inc. had recently produced an experimental defoliant product, designated as EC-3740 (25%). The product referred to is a 25% aqueous solution of disodium 3,6-endoxohexahydrophthalate.

Studies on Defoliant Action

The defoliant and the herbicidal actions of the 3,6-endoxohydrophthalates will be discussed in separate sections; however, it is pointed out that no sharp line of demarcation exists between these two physiological effects. A relevant point, is that the 3,6-endoxohydrophthalic acids and their salts induce maximum defoliation over an optimum range of dosage with considerably less accompanying herbicidal effects than the defoliants now being marketed.

A comparison with the effects of 2,4-D and its derivatives will be deferred for the section on studies of herbicidal action, because 2,4-D and its derivatives lack defoliant properties; contrarily, it is known that these materials induce the leaves, buds, and fruit to adhere more tenaciously.

String Beans.

In this work, concentrations of aqueous solutions, ranging from 0.01% to 1.0%, were deposited onto each primary leaf of young Black Valentine beans in the amount of 0.1 cc. per leaf. Results showed that excellent defoliation was induced usually by concentrations as low as 0.05% (i.e., at a rate of 0.05 mg. per leaf or of 0.1 mg. per plant). Table 1 shows the results of a typical test in which the effectiveness of 3321 is compared with that of several known defoliants. Table 2 presents data of a typical application which indicate that although both 3441 and 3321 possess excellent defoliant values, 3441 is effective at a lower dosage per plant than 3321.

Table 1

Effects of various defoliants 4 days after deposition on the primary leaves of young Black Valentine bean plants.

Material	% Concentration 0.02% (Amount of Chemical per Plant 0.04 mg.)			0.1% (0.2 mg.)			0.5% (1.0 mg.)		
	Abscission	Leaf burn	Trifoliate Shoot Weight (gms.)	Abscission	Leaf burn	Trifoliate Shoot Weight (gms.)	Abscission	Leaf burn	Trifoliate Shoot Weight (gms.)
Untreated	None	None	10.4	None	None	10.4	None	None	10.4
3321	None	None	11.0	5-Both 3-Single	Withered	7.0	8-Both	-	3.7
KOCN				None	Heavy	10.5	None	Heavy	10.4
NH_4SCN				None	Moderate	10.3	None	Heavy Chlorosis	10.5

Note: 0.1 cc. of each aqueous solution was deposited, usually as 7-9 drops, scattered fairly uniformly on the upper surface of each primary leaf of eight fairly uniform sized plants with undeveloped trifoliates. Abscission refers only to the treated primary leaves, and "single" and "both" indicate whether one or both leaves were abscissed. The inhibition of the trifoliate shoot development is reflected by the relative weights given.

Table 2

Effects of 3441 and 3321 seven days after deposition on primary leaves of young bean plants.

		% Concentration				
		0.031%	0.062%	0.125%	0.25%	0.5%
		Amount of chemical per plant				
Material	Kind of Effect	0.06 mg.	0.12 mg.	0.25 mg.	0.5 mg.	1.0 mg.
Untreated	Abscission	None				
	Leaf burn	None				
	Inhibition	15.6 g.				
3441	Abscission	2-single	1-single 9-both	5-single 11-both	4-single 12-both	16-both
	Leaf burn	Moderate	Shrivelled	Shrivelled	Shrivelled	-
	Inhibition	9.5 g.	2.6 g.	2.4 g.	1.9 g.	1.9 g.
3321	Abscission	None	2-single	2-single 10-both	8-single 7-both	2-single 14-both
	Leaf burn	None	Moderate	Shrivelled	Withered	Withered
	Inhibition	14.6 g.	10.0 g.	3.2 g.	3.3 g.	3.2 g.

Note: Sixteen plants were used per test.

A considerable number of greenhouse applications similar to those shown above were conducted in which the various salts of the two 3,6-endoxohydrophthalic acids were used. Results with these salts in each case closely parallel the results obtained using the free acids. In general, for field application, the use of salts is preferable in view of their non-corrosiveness to metallic equipment and of their ease of handling by operators.

Tables 3 and 4, based on typical tests, give additional evidence of the relative effectiveness of the disodium salt of 3441 (i.e. 3504) as compared with other defoliants. The plants used in these tests were young Dwarf Horticultural beans, with undeveloped trifoliate shoots. In Table 3 application was made by pipetting solutions onto the primary leaves in the manner similar to that mentioned above for Tables 1 and 2. The mode of application was that of dipping the top vegetation to the first (cotyledonary) node into various concentrations of aqueous solutions of each compound (Table 4). After being dipped, each plant was shaken to remove excess solution. Based on some weighings of dipped leaves of such plants, it is known that much larger amounts of chemical adhered to the plants as a result of dipping than were deposited on the primary leaves by pipetting. That this is correct is reflected in the effectiveness of all the defoliants at considerable lower concentrations in the dipping tests as compared with the pipetting tests. Sodium trichloroacetate was substituted for ammonium sulfamate in this particular test in view of the very low activity shown by the latter in previous experiments.

It will be noted that the order of defoliation activity and of phytotoxicity of the various defoliant-herbicides shown by dipping young bean plants into a series of concentrations of aqueous solutions of the active material is the same as that obtained by pipetting aqueous solutions onto only the primary leaves of the plants. One point deserves emphasis, for the tabulated data do not take this point into account: on making observations and records of tests, it was noted repeatedly that the various 3,6-endoxohydrophthalates almost always bring about abscission response considerably faster than do the other known defoliant chemicals. The time required for inducing defoliation of young bean plants, naturally, varies with climatic conditions, but the 3,6-endoxohydrophthalic acids and their salts usually induce either laminar or nodal abscission in from two to four days. Experimentation on both greenhouse and field plot scope showed definitely that more mature bean plants were likewise defoliated by spray applications of 3321, 3441, 3504, and 3739. In these tests with older bean plants, as in the case of young bean plants, the 3,6-endoxohydrophthalates were superior as defoliants to sodium pentachlorophenate, sodium chlorate, potassium cyanate, and ammonium thiocyanate. They were also superior to calcium cyanamide applied in dust form where water was sprayed on the leaves each morning in order to simulate dew during comparative tests.

Table 3. Effects of various defoliants ten days after deposition on primary leaves of young bean plants.

Material	Kind of Effect	0.006% — 0.012 mg.	0.012% — 0.025 mg.	0.025% — 0.05 mg.	0.05% — 0.1 mg.	0.1% — 0.2 mg.
		% Concentration / Amount of Chemical per Plant				
Amine Salt of 2,4-D	Epinastic	Severe	Dead	Dead	Dead	Dead
	Hormonal	Galls, primordial roots				
3504	Abscission	1-single	2-single	5-both	1-single 7-both	8-both
	Leaf burn	Withered	Withered	Withered	Withered	
	Inhibition	As controls	As controls	Severe	Severe	Severe
C_6Cl_5ONa	Abscission	None	None	None	None	None
	Leaf burn	Slight	Slight	Moderate	Severe	Severe
	Inhibition	As controls	As controls	As controls	As controls	As controls
$NaClO_3$	Abscission	None	None	None	None	None
	Leaf burn	Slight	Slight	Withered	Withered	Withered
	Inhibition	As controls	As controls	As controls	As controls	As controls
KOCN	Abscission	None	None	None	None	None
	Leaf burn	None	None	Slight	Moderate	Withered
	Inhibition	As controls	As controls	As controls	As controls	Slight
NH_4SCN	Abscission	None	None	None	None	None
	Leaf burn	None	None	Slight	Slight	Moderate
	Inhibition	As controls	As controls	As controls	As controls	As controls
Ammonium Sulfamate	Abscission	As controls	As controls	As controls	As controls	As controls
	Leaf Burn	"	"	"	"	"
	Inhibition	"	"	"	"	"

Note: Eight Dwarf Horticultural bean plants were used per test.

Table 4. Effects of various defoliants ten days after dipping of young bean plants.

Material	Kind of Effect	% Concentration 0.005%	0.01%	0.05%	0.25%	0.5%
3504	Abscission	2-Single 3-Both	1-Single 5-Both			
	Leaf burn	Severe	Severe			
	Inhibition	Moderate	Severe	Dead	Dead	Dead
C_6Cl_5ONa	Abscission		None	1-Single	3-Both	
	Leaf burn		Moderate	Severe	Withered	
	Inhibition		Slight	Severe	Severe	Dead
$NaClO_3$	Abscission		None	None	2-Single 4-Both	
	Leaf burn		None	Slight	Severe	
	Inhibition		None	Moderate	Severe	Dead
KOCN	Abscission		None	None	8-Both	3-Both
	Leaf burn		None	None		Withered
	Inhibition		None	None	Severe	Severe
NH_4SCN	Abscission		None	None	None	None
	Leaf burn		None	Slight	Moderate	Severe
	Inhibition		None	None	Slight	Severe
CCl_3COONa	Abscission		None	None	None	None
	Leaf burn		None	None	Slight	Shrivelled
	Inhibition		None	None	Moderate	Severe

Note: Eight Dwarf Horticultural bean plants were used per test.

Lima Beans.

Based on previous successful demonstrations on the defoliation of string beans with the disodium salt (3504), a field plot demonstration with this chemical as a defoliant for lima beans was conducted at Seabrook Farms, near Bridgeton, N. J., last fall in cooperation with several of the research personnel(6) of that organization. Four plots, each 100 sq. ft. in area, were sprayed with the following concentrations of aqueous solutions of 3504 at a constant volume of 100 gallons per acre: 1/8%, 1/4%, 3/8%, and 1/2%, respectively (i.e., 1, 2, 3, and 4 lbs. per acre). The lima bean plants were mature and had been harvested by hand picking and, at the time of the treatment, were bearing small bean pods which had developed subsequent to harvesting. Five days after spray applications, it was observed that the 1 lb. and the 2 lb. per acre plots gave a low degree of defoliation; that the 3 lbs. per acre plot gave only fair defoliation; but the plot sprayed at the rate of 4 lbs. per acre had given about 65% defoliation with quite a few of the adhering leaves easily dropping off on touching. Observations nine days after spray applications indicated that about 75% of the leaves had abscissed with some adhering leaves still dropping off on touching. Practically none of the bean pods had abscissed and there was no evidence of damage to the beans in the pods. One of Seabrook's cooperators explained that, in their practice of harvesting lima beans for processing in their quick-freeze units, the bean plants are uprooted by a special machine and the uprooted plants then are transferred by conveyor belt system to trucks for removal to their factories. It was believed that the rather rough handling of the uprooted bean plants during harvesting and conveyance to the factories should cause a fair percentage of the loosened leaves to drop off the plants. The Seabrook research personnel believed that the defoliation results obtained at the 4 lbs. per acre rate were quite satisfactory and, based on this demonstration, have indicated a desire to carry on much more extensive work with this new defoliant in 1950.

Hydrangeas.

A New Jersey florist brought to our attention his need, and the general need of other florists who grow hydrangea plants for the Easter trade, for a defoliant which could be used in the fall to defoliate the plants before bringing them into the greenhouse for forcing new growths during the winter months. It was explained that if the plants were left out of doors in order to attempt defoliation by means of frost, there was the risk that a sudden heavy frost might seriously injure or kill the plants; on

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(6) Grateful acknowledgement is made to the friendly cooperation of Messrs. Abrams, Parmalee, and Burgess of Seabrook Farms

the other hand, too light a frost would not induce defoliation. In initial demonstrations, spraying was carried on with the unsaturated anhydride, 3321, and the saturated acid, 3441. Two separate demonstrations were made, plants averaging about one foot high. A volume of approximately 30 cc. of spray was used to wet each plant thoroughly.

In the first demonstration, hydrangea plants were sprayed with aqueous solutions of the unsaturated anhydride, 3321, at the following concentrations: 1/64%, 1/32%, 1/16%, and 1/8%. These concentrations correspond to approximately 5, 10, 19, and 38 mg. per plant, respectively. Observations two days after spraying indicated the following results: no abscission had occurred at 1/64% and 1/32%; some of the leaves had abscissed at 1/16%; practically complete abscission had occurred at 1/8%. No damage was evident at the lower concentrations, but light damage to the terminal shoot was evident at 1/8%.

In the second demonstration, two plants for each concentration were similarly sprayed with the saturated acid, 3441, at the following concentrations: 1/16%, 1/8% and 1/4%, respectively. Observations two days after spraying indicated that excellent defoliation had occurred at all concentrations; at 1/8% and 1/4% there was some light damage to terminal shoots.

All hydrangea plants were later kept in the greenhouse where new leaves developed and growth, in general, proceeded normally.

Cotton[7].

It is well known to research workers on cotton defoliation that young cotton plants do not respond to any marked degree when the better known cotton defoliants are applied to such plants; however, a few greenhouse demonstrations with potted young cotton plants were made. The results obtained in one such typical demonstration with young Deltapine cotton bearing from three to five leaves at the time of application are given in Table 5. In this demonstration, 0.2 cc. of several concentrations of aqueous solutions of the following compounds were deposited on the first three developed leaves: 3321, ammonium thiocyanate (NH_4SCN) and potassium cyanate ($KOCN$).

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(7) The authors are especially indebted to Dr. W. H. Tharp, U. S. D. A. investigator, Fayetteville, Arkansas, and the large group of federal and state cotton defoliation research cooperators who have field-tested these new defoliants under a variety of conditions. It is expected that these cooperators will publish their results seperately.

From the data given in Table 5, it will be noted that 3321 is considerably more phytotoxic and has considerably better defoliant value than potassium cyanate and ammonium thiocyanate, when applied to the leaves of young cotton plants. The results obtained in this demonstration and in another demonstration show that the acid anhydride, 3321, offers promise as a practical cotton defoliant.

In view of these promising results obtained with 3321 as a defoliant, Deltapine cotton seeds were planted in rows in a field near the Palmyra, N. J. laboratory. Unfortunately, there was insufficient time for cotton plants to mature before frost killed them; however, several field plot demonstrations on 3321 compared with other defoliant-herbicides were conducted when the cotton plants, about 2 to 2 1/2 feet high, were mainly in the flowering stage with only a few in either square or boll stage. The results of one typical case are given in Table 6. In this case, plants were sprayed in a fairly uniform manner at the volume rate of 185 gals. per acre with 1/8% and 1/4% concentrations, respectively, of aqueous solutions of the following chemicals: 3321, $NaClO_3$, and NH_4SCN. These concentrations correspond to approximately 2 lbs. and 4 lbs., respectively, per acre.

It will be observed from Table 6 that the order of both phytotoxic and defoliant effectiveness of the three chemicals was as follows: 3321, $NaClO_3$, NH_4SCN. Despite a degree of plant damage which was obtained by spraying with a 1/8% aqueous solution of 3321 at the rate of 2 lbs. per acre, the fact that approximately 25% of the leaves had abscissed within four days after application at this rather low rate showed suitabilities of 3321 for more practical field applications to mature cotton, that is, cotton having a considerable percentage of open bolls ready for harvesting.

In the late fall, field demonstrations on mature cotton were conducted in Louisiana. These demonstrations were carried out under somewhat adverse conditions, and, although exact rates of application were not established, it was shown definitely that 3321 and 3441 were effective field defoliants for mature cotton plants. It was noted also that no significant boll injury occurred. More exact and much more extensive demonstrations were conducted in the Lower Rio Grande Valley.[a] Results here show that 3504 was highly effective in dosages of from 3 to 5 pounds per acre. It was observed that this compound gave good defoliation in a field in which only approximately one boll for each 10 plants had opened and in another field which already had been picked. A rather unusual feature was that most of the leaves abscissed while still quite green. A number of other field cotton defoliation demonstrations was made later in the season and showed that the dosage might be considerably lowered if appropriate amounts of an efficient wetting agent were employed in the spray solution. Thus, good defoliation has been obtained recently with less than one pound of 3504 per acre.

Table 5. Effects of several defoliants 15 days after deposition on the first three developed leaves of very young cotton plants.

Material	Kind of Effect	% Concentration 0.05% / Amount of chemical per plant 0.1 mg.	0.1% / 0.2 mg.	0.25% / 0.5 mg.
Untreated	Abscission	None		
	Development	Plants developing normally; 3d node leaves, large; 4th node leaves, medium.		
3321	Abscission	3-two leaves 5-three leaves	5-three leaves 3-died	2-two leaves 6-died
	Burning	None	Shrivelled	Withered
	Inhibition	None	Severe	Severe
KOCN	Abscission	None	3-single leaves 2-both leaves	7-both leaves
	Burning	None	None	None
	Inhibition	None	None	None
NH_4SCN	Abscission	None	None	None
	Burning	None	Moderate	Heavy
	Inhibition	None	None	None

Note: Eight plants were used per test. Inhibition refers to the degree of trifoliate shoot development. Abscission refers to the number of plants which had single, two, or three leaves per plant defoliated.

Table 6. Effects of several dofoliants 4 days and 26 days after spray applications on immature cotton.

Material	Kind of Effect	Amount per acre			
		2 lbs. per acre		4 lbs. per acre	
		After 4 days	After 26 days	After 4 days	After 26 days
3321	Abscission	25%	25%	20%	20%
	Leaf burning	Heavy to shrivelled	Withered	Withered	Withered (plants dying)
	Stem burning	Light	Light	Moderate	Heavy
$NaClO_3$	Abscission	None	None	10%	10%
	Leaf burning	Heavy to shrivelled	Shrivelled	Shrivelled	Shrivelled to Withered
	Stem burning	Light	Moderate	Moderate	Heavy
NH_4SCN	Abscission	None	None	None	Heavy
	Leaf burning	None	None	Light	Light
	Stem burning	None	None	None	None

Note: Plants were in flowering stage with a relatively few squares and quite small bolls.

Miscellaneous Defoliation Tests.

A considerable mass of data show the ability of 3504 and related forms of 3,6-endoxohydrophthalic acids to induce defoliation of miscellaneous trees and shrubs. From a practical viewpoint, it is known that nurserymen, for example, desire to defoliate certain trees and shrubs, especially ornamental plants, for shipment and for other purposes. Two examples of defoliation responses induced in various species of plants are presented.

Example 1. Transplanting of holly plants usually results in considerable loss unless the leaves are removed before shipment. Manual plucking of the leaves is a tedious and expensive process. In one test, American holly bushes, approximately 15 inches high, were sprayed to thorough wetting with 0.1%, 0.5%, and 1.0% aqueous solutions of 3504. All solutions contained 0.1% of a non-ionic wetting agent. Four plants were treated at each concentration. Average defoliation was 30% for the 0.1% treatment; 58% for the 0.5% treatment; and 84% for the 1.0% treatment. All plants survived transplanting and resumed growth quickly.

Example 2. Further evidence as to the defoliating response of woody plants to 3504 is given in Table 7. One to several twigs on a number of trees and shrubs were sprayed with 0.5, 1.0, 2.0, and 4.0 percent aqueous solutions of 3504.

Table 7. Defoliation response of woody plants to 3504 and calcium cyanamid, 13 days after treatment

Plants treated	Treatments: Disodium 3,6-endoxohexahydrophthalate (3504), Percent						Calcium cyanamid	Checks
	0.05%	1.0%	2.0%	4.0%	6.0%	10.0%	100%	-
Aralia spinosa	-	62	52	48	26	20	55	0
Berberis thunbergi	-	-	82	79	94	47	83	0
Cephalanthus occidentalis	-	51	69	98	93	96	38	3
Cercis canadensis	-	77	9	9	0	8	92	0
Chaenomeles lagenaria	-	98	96	94	90	96	76	0
Chilopsis lineris	-	85	39	39	21	44	47	0
Continus americana	-	34	19	5	34	81	5	0
Cornus officinalis	-	100	100	100	100	100	100	0
Eleagnus angustifolia	-	41	15	11	13	11	86	0
Eleagnus umbellata	-	62	79	93	-	-	100	5
Euonymus atropurpurea	-	-	-	-	100	74	98	11
Fontanesia sp.	-	61	63	5	17	9	62	0
Forsythia suspensa	-	-	-	-	70	61	4	0
Gooseberry	27	50	90	37	-	-		
Hibiscus syriacus	100	100	100	88	-	-	8	4
Kolkwitsia amabilis	-	100	100	100	-	-	88	0
Ligustrum sp.	100	100	100	100	-	-	100	0
Lombardy poplar	-	8	86	36	-	-		

Table 7 (Cont'd.) Defoliation response of woody plants to 3504 and calcium cyanamid, 13 days after treatment

Plants treated	Disodium 3,6-endoxohexahydrophthalate (3504) Percent 0.05%	1.0%	2.0%	4.0%	6.0%	10.0%	Calcium cyanamid 100%	Checks -
Lonicera fragrantissima	-	-	-	81	92	76	18	0
Lonicera tatarica	-	-	85	92	98	100	34	0
Mulberry	20	18	-	23	-	-		
Peach	92	100	100	100	-	-		
Philadelphus sp.	-	-	-	-	38	100	92	0
Pinus nigra	-	0	0	0	31	81	0	0
Populus nigra	48	28	38	20	-	-	76	0
Purple-leaf plum	-	15	5	3	3	8	18	58
Quince	73	60	-	-	-	-		
Rhamnus sp.	-	78	81	89	85	86	88	0
Rhus aromatica	-	-	-	-	50	77	22	0
Rhus glabra	-	-	-	-	-	-	0	0
Spiraea vanhouttei	-	82	72	88	89	83	65	0
Staphylea trifolea	-	-	-	-	92	25	63	36
Symphoricarpos orbiculatus	0	0	70	13	-	-		
Syringa sp.	-	20	58	61	33	9	92	0
Toxylon pomifera	-	92	100	60	52	34	100	8
Viburnum prunifolium	-	98	78	49	89	87	88	0
Viburnum sp.	-	-	-	55	55	81	0	0
Winesap apple	-	58	70	95	85	98	89	0

Herbicidal Action

The 3,6-endoxohydrophthalic acids in addition to being effective defoliants, have unusually high herbicidal action. They have been compared with a large number of currently used chemical herbicides, and are of an order of effectiveness greater than compounds heretofore used commercially, with the exception of 2,4-D. Generally, 2,4-D is much more effective against the broad-leafed plants than are the 3,6-endoxohydrophthalates. However, there are certain broad-leafed plants, such as the goldenrod which may be killed by these new herbicides more quickly and at lower amounts per acre than by 2,4-D. Also, in many cases where the susceptibility of the crop plant to 2,4-D prevents its use, these materials are effective in post-emergence weed control of even the broad-leafed weeds in these particular crops. The most significant advantage of these new herbicides in comparison with 2,4-D is that the new materials are effective agents for the killing of many species of grassy weeds. Thus direct competition is not visualized between the 3,6-endoxohydrophthalates and 2,4-D, but rather the use of these two types of compounds so each may supplement the other in practical application.

For the control of the grasses, many chemicals have been recommended or suggested. All of these require economically exorbitant dosages per acre. The 3,6-endoxohydrophthalic acids and their salts give effectiveness at comparatively low dosages.

Representative data on various herbicidal uses of the 3,6-endoxohydrophthalates are given in the four following subdivisions.

Post-emergence Applications.

Some examples of post-emergence applications of several forms of the 3,6-endoxohydrophthalates are presented below. These examples refer mainly to early tests in which no wetting agent was used, or in which quite low concentrations of wetting agent were used. Also, in early cotton defoliation tests, no wetting agent was used. Subsequent cotton defoliation and herbicidal application have shown that it is possible to reduce considerably the rate of active ingredient when high concentrations of wetting agent are used in conjunction with the active ingredient.

Example 3. A sweet potato plot in which the plants were approaching maturity was sprayed with a 0.5% aqueous solution of 3321 at the rate of 150 gallons per acre (i.e. 6 lbs. 3321 per acre). In twelve days practically all of the leaves had abscissed, the adhering leaves being withered with completely dehydrated blades and petioles; some of the vines had blackened but most were still green.

Example 4. A weed plot in which flowering morning glories predominated was sprayed with a 1% aqueous solution at 100 gals. per acre (i.e. 8 lbs. 3321 per acre). In a week the plants were badly injured and in four weeks the plants had died.

Example 5. A weed plot in which ragweed was the dominant weed species was sprayed with a 1% aqueous solution of 3321 to which 0.1% Nonic 218[8] was added as a wetting agent, at the rate of 110 gals. per acre (i.e. 9 lbs. 3321 per acre). In a month all plants had died.

Example 6. Smartweed plants 4 to 5 feet tall were sprayed with a 1% aqueous solution of 3321 at 77 gals. per acre (i.e. 6 lbs. per acre). In 10 days most of the leaves were considerably withered, the terminal portions of the stems were considerably dehydrated, and most of the seeds borne on the terminal portions of the plants were dehydrated.

Example 7. A weed plot in which a species of goldenrod in flower, the plants averaging about 4 feet high, was sprayed with a 0.5% aqueous solution of 3321 at 200 gals. per acre (i.e. 8 lbs. per acre). In three weeks about 25% of the plants had died and the rest were dying, as was indicated by the withered leaves and flowers and by the severely dehydrated stems. In contrast, a similar plot sprayed with a triethylamine salt of 2,4-D at the same concentration and volume per acre, showed severe damage to the plants in three weeks, but somewhat less effect than the 3321-sprayed plot.

Example 8. A weed plot in which switchgrass, averaging 6 feet high, was the dominant weed, was sprayed with a 1% aqueous solution of 3321, to which 0.1% Nonic 218 was added as a wetting agent, at the rate of 185 gals. per acre (i.e. approximately 16 lbs. 3321 per acre). In two weeks the plants were badly injured, much more so than similar plots sprayed with 2,4-D and with sodium pentachlorophenate at the same rate per acre.

Example 9. A one-half percent aqueous solution of 3441 was used to spray potted plants, at dosages calculated to be from 0.38 to 18 pounds per acre. Pots containing relatively mature rye plants evidenced considerable burning of the leaves at dosages below two to four pounds per acre. At dosages above this range, the plants were killed. Corn, another monocotyledon, behaved in a similar manner. The corn plants used were approximately two weeks old. Young shoots of alfalfa were slightly more sensitive.

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(8) Manufactured by Sharples Chemicals Inc.

Example 10. Aqueous solutions of various concentrations of 3504 were prepared. Various plant species were sprayed with these solutions until the plants were wet thoroughly. The results of the tests are summarized in the following table.

Table 8

Plant species	Concentration of solution	Days after treatment	Plant injury
Plantain (broad-leafed)	1%	8	Very severe
Plantain (narrow-leafed)	1	8	" "
Dock	1	3 and 8	" "
Henbit	2	3	" "
Dandelion	4	3 and 8	Severe
Chickweed	1	8	Very severe
White clover	1	8	" "
Shepherd's purse	2	3 and 8	Moderate
Bluegrass	2-10	8	Very severe

Example 11. A series of comparative tests was made for the purpose of comparing the phytotoxicity of 3441 acid with that of sodium trichloroacetate toward various plant species. In some tests, the acid was used per se; in other tests it was used in the form of one of its chemical equivalents, namely, the disodium salt. The chemicals in aqueous solution were sprayed onto various plant species at rates designed to give a known application in terms of pounds of active ingredient per acre. The comparative data are summarized in Table 9.

Table 9

		3441		3504		Sodium Trichloroacetate	
Plant species	Age or size of plants	lbs. per acre	Plant injury	lbs. per acre	Plant injury	lbs. per acre	Plant injury
Oxalis	young	9	very severe			30	killed
Oxalis	mature			18	severe	30	severe
Wheat	14 days	9	very severe			120	very severe
Wheat	1 month			18	very severe	120	killed
Colby milo	1" high			12	very severe	60	very severe

Table 9 (Cont'd.)

Plant species	Age or size of plants	3441 lbs. per acre	3441 Plant injury	3504 lbs. per acre	3504 Plant injury	Sodium Trichloroacetate lbs. per acre	Sodium Trichloroacetate Plant injury
Oats	13 days	3 to 12	severe			120	very severe
Oats	28 days			24	very severe	120	very severe
Balbo rye	28 days			18	killed	120	killed
Cabbage	17 days	18	killed			60	very severe
Cabbage	28 days			24	very severe	60 to 120	severe
Black locust	seedlings			6	killed	60	killed
Carrots	25 days			18	very severe	60	very severe
Bluegrass				18	killed	60	killed
Potatoes	3" to 4" high			6 to 30	severe	180	very severe
Potatoes	6" to 7" high			60	killed	180	very severe
Bermuda grass	1 year	3 to 30	none			120	very severe
Bermuda grass	1 year			60	slight		
Bermuda grass	1 year			240	severe		
Cocklebur	young			1.5	killed	30	slight to severe
Cocklebur	9" high			6	killed	120	severe
Foxtail	3/4" to 2" high			6 to 15	severe to killed	15	very severe

Table 9 (Cont'd.)

Plant species	Age or size of plants	3441 lbs. per acre	3441 Plant injury	3504 lbs. per acre	3504 Plant injury	Sodium Trichloroacetate lbs. per acre	Sodium Trichloroacetate Plant injury
Crabgrass	3/4" to 2" high			15	severe to killed	15	severe to killed
Giant ragweed				3	very severe	30	severe
Mare's tail				6	very severe	30	severe
Wild buckwheat				6	killed		
Wild lettuce				3	severe	30	killed
Dock				18	killed	30	moderate
Henbit				6	severe to very severe	30	moderate
Bindweed				12	killed	12	moderate
Sowthistle				30	killed	30	moderate
Hairy chess				3	killed	18	moderate
Purslane				6	severe	30	slight
"				12	killed		
Lamb's-quarters				18	slight to severe	18	moderate
Milkweed				12 to 30	severe	30	slight
Wild mustard				3	severe	30	severe
Wild mustard				12	killed		
Pepper grass				12	killed	30	moderate
Pigweed (seedlings)				3	killed	30	severe

Example 12. Each of two flats (22" x 15" x 4" deep) containing sandy loam soil was planted with 20 onion sets and a mixture of weed seeds of undetermined species. When the onions were about 6 inches high and the weed seedlings from 1 inch to 3 inches high, the soil and plants of one flat were sprayed with an aqueous solution of 3504, the rate of application of active ingredient being 10 pounds per acre. The other flat was not treated but was used as a control. In the treated flat, the tops of the onion plants were burned lightly, and the weed seedlings were destroyed within three days. The onion plants soon recovered, however, and continued to grow as well as those in the control flat, over a three-week observation period.

Example 13 (summary of post-emergence work). Based on a series of applications in which several forms (3321, 3441, 3504, and 3739) of the 3,6-endoxohydrophthalate group were sprayed at various concentrations on a large number and a wide variety species of weed, crop, and woody plants, the plant species were classified as to the herbicidal effectiveness of the compounds. Most of this work was done at Kansas State College[9]. The plants are classified as: susceptible (S); intermediate (I); and resistant (R).

In presenting this classification, it is emphasized that this is based on the best presently available evidence. The viewpoint regarding the present classified list is the same as that held by the Western Weed Control Conference[b] in the Eighth Annual Meeting, 1946, regarding the adoption of the classified list on the response of various plant species to 2,4-D. This viewpoint was stated as follows:

> "List of annual weeds, winter annual weeds, and a few perennial lawn weeds, classified as 'generally susceptible', 'intermediate' or 'resistant' to 2,4-D. Obviously no clear line can be drawn between these different classes. Among many other factors, the age and condition of the plant are important. Many of the weeds in the 'susceptible' list below are moderately resistant to 2,4-D at the bloom or older stages. There are also discordant reports regarding many plants so that this is to be considered a temporary progress report, not a final placing of the weeds listed. We know far too little as yet about the variations, and susceptibility within and between species and the reasons for these variations. Also, obviously, the lists are in no sense complete."

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(9) Grateful acknowledgement is made to Dr. Dale Wolf and Dr. Gilbert Ahlgren, Dept. of Agronomy, N. J. Agricultural Experiment Station, New Brunswick, N. J., for their kind cooperation in testing 3504 as a post-emergence spray against a considerable number of crop species of plants and for submitting a list of several which were relatively uninjured by 3504 at the rate of 4 lbs. per acre.

It will be noted from Table 10, under the list of crop plants, that several cruciferous crop plants (cabbage, kale, kohlrabi, rape, rutabaga, and turnips), several grain crops (Colby milo, corn, and wheat) and several other crop plants (carrots, onions, and sugar beets) appear to be resistant to 3,6-endoxohydrophthalates. Since it is known that cruciferous plants in general, and, also, carrots, onions, and sugar beets are quite susceptible to 2,4-D, the 3,6-endoxohydrophthalates may be used as selective weed killers on post-emergence treatments of these particular crops with which 2,4-D cannot be used. Too, the 3,6-endoxohydrophthalates have value in post-emergence applications alone to control weeds selectively in fields of certain grain species or to supplement 2,4-D or other currently-used herbicides, especially where grassy weeds are predominant. It is relevant to point out here that the 3,6-endoxohydrophthalates have shown much greater effectiveness in the control of grassy weeds as a class, than have any of the currently-used herbicides.

Table 10

Effects of various forms of 3,6-endoxohydrophthalates on certain plant species.

(S - susceptible; I - intermediate; R - resistant)

Common Name	Scientific Name	Value
	Weeds	
Bermuda grass	Cynodon dactylon (L.) Pers.	R
Bindweed	Convolvulus arvensis L.	S - I
Bluegrass	Poa pratensis L.	R
Broad-leafed Plantain	Plantago major L.	S
Buckwheat, False Climbing	Polygonum scandens L.	S
Chickweed	Stellaria Sp.	S - I
Clover, White	Trifolium repens L.	S
Cocklebur	Xanthium pensylvanicum Wallr.	S
Crabgrass	Digitaria sanguinalis (L.) Scop.	I - R
Dandelion	Taraxacum vulgare Lam.	I - R
Dock	Rumex crispus L.	S - I
Dogbane	Apocynum sibiricum L.	R
Foxtail	Alopercurus carolinianus Walt.	I
Garlic, wild	Allium canadense L.	R
Goldenrod	Solidago sp.	I
Hairy Chess	Bromus japonicus Thunb.	S
Henbit	Lamimum amplexicaule L.	S
Hoary Verbena	Verbena stricta Vert.	I
Honeysuckle	Lonicera sp.	R
Ironweed	Veronia baldwini Torr.	R
Lamb's-quarters	Chenopodium album L.	I - R
Lettuce, wild	Latuca sp.	S
Mare's-tail	Hippuris vulgaris L.	S

Table 10 (Cont'd.)

Effects of various forms of 3,6-endoxohydrophthalates on certain plant species.

(S - susceptible; I - intermediate; R - resistant)

Common Name	Scientific Name	Value
	Weeds	
Milkweed	Asclepias sp.	R
Mustard, wild	Brassica kaber (Dc.)	S
Peppergrass	Lepidium densiflorum Schrad.	I
Pigweed	Amaranthus hybridus L.	S - I
Pigweed	Chenopodium boscianum Mog.	R
Plantain	Plantago sp.	S
Primrose	Oenothera laciniats Hill.	I - R
Purslane, common	Portulaca oleracia L.	I
Ragweed, Giant	Ambrosia trifida L.	S - I
Ragweed	" artemisifolia L.	S
Smartweed	Persicaria pensylvanicum L.	I
Shepherd's Purse	Capsella bursa-pastoris (L) Medic.	S - I
Snow-on-the-Mountain	Euphorbia marginita Pursh.	I
Sow Thistle	Soncus sp.	R
Sunflower, common	Helianthus annus L.	S
Three-seeded mercury	Acalyph ostryaefolia Riddell.	I
Tick Trefoil	Desmodium sp.	S
Venus' Looking-glass	Specularia perfoliata L.	I
Veronica	Veronica peregrina L.	S
Vetch	Vicia villosa Roth.	S
Water Hyacinth	Eichornia crassipes Solms.	I
Water Lily	Nymphaea odorata	I
Wood Sorrel	Oxalis repens Thunb.	S - I
Wood Sorrel	" stricta L.	R
	Crops	
Barley (seedlings)	Hordeum sativum Jess.	S
Bean, Limas	Phaseolus lunatus L.	I
Bean, String	" vulgaris L.	S - I
Beet, Sugar	Beta vulgaris L.	R
Buckwheat	Fagopyrum esculentum Moench.	S - I
Cabbage	Brassica oleracea L.	R
Carrot	Daucus carota L.	I - R
Colby Milo	Andropogon sorghum vulgaris Hackel.	R
Corn (Pride-of-Saline)	Zea mays L.	I - R
Cotton, mature	Gossypium hirsutum L.	I - R
Kale	Brassica oleracea acephela L.	R
Kohlrabi	" oleracea gongylodes L.	R
Oats	Avena sativa L.	I - R
Onion	Allium cepa L.	R
Peas, garden	Pisum sativum L.	S

Table 10 (Cont'd.)

Effects of various forms of 3,6-endoxchydrophthalates on certain plant species.

(S - susceptible; I - intermediate; R - resistant)

Common Name	Scientific Name	Value
	Crops	
Pepper, ornamental	Capsicum sp.	I - R
Potatoes, white	Solanum tuberosum L.	I - R
Potatoes, sweet	Ipomoea batatas Lam.	S
Rape	Brassica rapa L.	R
Rutabaga	" oleracea L.	R
Rye, Balbo	Lolium perenne L.	I
Soybeans, Gibson	Soga max	I
Tomatoes (Mich. State Forcing)	Lycopersicum esculentum Mill.	S
Turnips	Brassica campestris L.	R
Wheat	Triticum sativum vulgare Hackel.	R
	Woody plants	
Blackberry	Rubus allegheniensis Bailey	R
Cherry, Wild Black	Prunus pensylvanica L.	R
Cherry, Wild Red	" serotina Ehrh.	R
Coral Berry	Symphoricarpos orbiculatus Moench	I - R
Elm	Ulmus americana L.	I
Gooseberry	Ribes missouriense Nutt.	R
Hackberry	Celtis occidentalis L.	R
Holly, American	Ilex opaca	R
Hydrangea	Hydrangea hortensia, Siebold	I - R
Locust, Black (seedlings)	Robinia pseudo-acacia L.	S
Persimmon, common	Diospyros virginiana L.	I
Pokeberry	Phytolacca decandra L.	I
Rose	Rosa sp.	R
Sumac, smooth	Rus glabra L.	I

Pre-Emergence Applications[10].

Example 14. Eight plots of ground 10' by 20' and separated by control strips were planted with corn in rows 1 foot apart. Duplicate plots were sprayed one day after planting with aqueous solutions of 3504 at four different rates, one rate for each set of duplicate plots. The rates were 2 pounds, 3 pounds, 4 pounds, and 5 pounds of active ingredient per acre respectively.

Weeds (of which spurry was the dominant species) on the plots sprayed at the rate of two pounds per acre were retarded slightly for about one week. In the plots sprayed at the rate of three pounds per acre, the weeds were retarded considerably for about two weeks with an evident diminution in number and size. On the plots sprayed at the rates of 4 and 5 pounds per acre, very few weeds developed, and these few were retarded materially. No injury to the corn was evident in the plots sprayed at the rate of 4 pounds per acre and below, and only slight stunting was evident in the plots sprayed at the rate of 5 pounds per acre.

Example 15. Four rows, 18 inches apart, of each of the following crop species were planted lengthwise in a cultivated sandy-loam field, 40 feet by 24 feet: buckwheat, cotton, cucumbers, and oats. The field was divided into four plots, 20 feet by 16 feet, one of which was untreated and three of which were treated one day after planting, with aqueous solutions of 3504 at 0.062%, 0.125%, and 0.25% concentrations, respectively. A constant volume of 200 gallons per acre was used on each of the treated plots. Thus the plots were treated at the following rates of active ingredient: untreated, 1.1 pounds per acre, 2.2 pounds per acre, and 4.4 pounds per acre. Observations over a period of two months showed that all of the treated plots set back the development and reduced the number of each of the various species of weed seedlings without any evident damage to the crop species. Both the number and the size of the weeds varied inversely with the increasing amounts of the herbicidal chemical per acre; however, it was deemed that the 1.1 pound per acre treatment was inadequate, that the 2.2 pound per acre treatment was fair, and that the 4.4 pound per acre treatment was excellent. The number of chickweed and bindweed plants at the 4.4 pound per acre rate was negligible as compared with those in the untreated plot; also, those chickweed and bindweed plants which developed in the 4.4 pound per acre plot were small compared with those in the untreated plot. Only one species of weed, lamb's-quarters, developed well in the 4.4 pound per acre plot.

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(10) In a private communication Dr. L. M. Stahler, U. S. D. A. Agronomist, Brookings, South Dakota, has advised the authors of a considerable amount of very successful exploratory work on the use of the 3,6-endoxohydrophthalates as pre-emergence treatments for a number of crops. Dr. Stahler plans to publish his results soon. His interest in these new herbicides has been of considerable value and is appreciated by the authors.

Seed Applications.

The 3,6-endoxohydrophthalates were tested by the seed germination procedure of Ready and Grant(c). The following examples tabulate the results obtained:

Example 16. The degree of inhibition of development of the primary roots and shoots, respectively, of germinating cucumbers by 3441 as compared with other herbicides was determined by pipetting 15 cc. of each of several concentrations of aqueous solutions of the chemicals into individual 150 mm. petri dishes in each of which 25 seeds were placed. Four replicate tests were used for each concentration. The average length in mm. of the roots and of the shoots after incubation for 6 days are shown in Table 11. The germination in each dish ranged from approximately 90% to 100%.

Table 11

Material	1 ppm		10 ppm		100 ppm		1000 ppm	
	roots	shoots	roots	shoots	roots	shoots	roots	shoots
Controls (water alone)	65	65	65	65	65	65	65	65
3441	60	60	12	30	7	7	2	0
NH_4SCN	C	C	C	C	C	25	22	7
KOCN	C	C	C	C	C	C	27	27
$NaClO_3$	C	C	C	C	C	C	C	C
Na pentachlorophenate	C	C	42	40	2	2	2	2

C - in each case so designated, the length of the primary roots and of the shoots was evaluated by inspection to be substantially the same as for the controls.

2,4-D is not included in Table 11 but in a number of tests it has given inhibition at approximately 0.1 ppm.

Example 17. The degree of inhibition of growth of germinating rice seedlings caused by 3441 was determined by pipetting 15 cc. of various aqueous concentrations of the compound into 150 mm. petri dishes in each of which 25 seeds were placed. Tests were run in duplicate, and the seeds were incubated for seven days. In columns A of Table 12, the average percentages of germination at each concentration of the acid have been directly compared with the average percentage of germination in water alone, which is 82%. In columns B of Table 12, the total weight of the seedlings at each concentration of the acid has been compared directly with the total weight of the control seedlings, and the ratio has been expressed in percentage, assigning a value of 100% to the controls.

Table 12

	1 ppm		10 ppm		100 ppm		1000 ppm	
Material	A	B	A	B	A	B	A	B
Controls	82%	100%	82%	100%	82%	100%	82%	100%
3441	80	91	86	39	46	15	0	-

Example 18. The comparative degree of inhibition of growth of germinating cucumber seedlings caused by 3441, 3504, and 3739 was determined by pipetting 15 cc. portions of aqueous solutions of various concentrations of these compounds into 150-mm. petri dishes in each of which 25 seeds were placed. Tests were run in duplicate, and the seeds were incubated for 8 days. The seeds in untreated controls germinated 100%. Germination of the treated seeds varied from 92% to 100%. In Table 13, the total weight of the treated seedlings at each concentration of each of the experimental chemicals has been compared directly with the total weight of the untreated seedlings. The ratio in each case has been expressed in percentage, with a value of 100% assigned to the controls (water alone).

Table 13

Concentration	Inhibition of growth compared with controls as 100%		
ppm.	3441	3504	3739
Controls	100%	100%	100%
10	73	69	76
25	77	70	74
50	59	68	65
100	57	58	64
250	46	46	54
500	37	40	40
1000	34	32	33

It will be noted that the free acid (3441), its disodium salt (3504), and its bis-triethylamine salt (3739) gave the same degree of inhibition of growth of cucumber seedlings.

Tree and Shrub Applications.

Some woody plants were treated by injection and by making the materials available for absorption by the root system. Examples of these modes of application are given below.

Example 19. A few roots of blackberry bushes, 4 to 6 feet high, were exposed by spading. The terminal portion of a wounded root of each bush was placed in a small bottle containing 10 cc. of a 0.1% aqueous solution of 3504. It was noted that within two days, each bush had absorbed the 10 cc. of solution and apparently had died.

Example 20. Some roots of a wild cherry bush 8 feet high were exposed by spading. The terminal portion of a wounded root was placed in a bottle containing 200 cc. of a 0.5% aqueous solution of 3504. The bush absorbed the solution, and in three weeks the bush apparently was dead.

Example 21. Holes 1/4 inch in diameter by 1 inch deep were drilled on a downward slant into thornapple and elm trees which were from 4 to 5 inches in diameter. One hole was drilled into each tree approximately 4 feet above ground level. Each hole was fitted with a small rubber tube which was sealed in by means of heavy grease and sealing wax. This tube was filled with the treatment solution and inverted into a 4-ounce bottle containing 100 cc. of the same solution. The bottle was suspended above the hole in such a manner that the material would siphon slowly from the bottle into the tree.

At a time after the tree buds had begun to swell in the spring but before they actually had burst open, two thornapple trees each were treated with 1%, 10% and 25% solutions of 3504, respectively. These treated trees burst their buds in a manner very similar to neighboring untreated trees. Approximately 3 days after the buds had opened, the 10% and 25% solutions had killed the young leaves. The 1% solution somewhat retarded development of the leaves but did not kill them. The trees treated with 1% solution recovered after approximately a month, while the trees treated with higher concentrations still appeared to be dead at the end of three months.

Elm trees similarly treated showed little effect at 1% while the 10% and 25% solutions greatly retarded the development of the young leaves. After 6 weeks the leaves still were extremely small and it was only near the end of the growing season that they had developed as fully as those of the untreated trees.

Elm and thornapple trees were treated similarly approximately 6 weeks after the leaf buds had opened. The effect on the thornapple trees was very similar to that above except that the 1% solution did kill some of the leaves. The elm trees were unaffected at 1%, a portion of the limbs were killed at 10%, and apparently the trees were killed at 25%. In a clump of thornapple trees, two of which seemingly were connected by an underground root system but showed separate above ground trunks, a treated trunk and one other trunk were killed by the 10% solution employed.

One large elm tree, approximately 14 inches in diameter at breast height, with fully developed leaves, was treated on opposite sides of the trunk with two 100-cc. portions of a 25% solution of 3504 in the above described manner. This solution was absorbed into the tree within 6 hours and wilting of the leaves was apparent within 24 hours. This wilting commenced at the top of the tree and at the ends of the large branches. Defoliation had commenced at the end of 2 days and after 5 days was at least 95% complete. The majority of leaves that abscissed were quite green. This tree showed no signs of recovery at the end of 3 months.

Translocation Effects

A number of tests have been conducted which demonstrate that the 3,6-endoxohydrophthalate can be translocated within treated plants (i.e. physiological responses have been observed in regions removed from the areas of application of the chemicals). In addition to the examples given below, the previous section on the treatment of trees and shrubs also contains information relevant to translocatory effects.

Localized Application Tests.

Early application with the 3,6-endoxohydrophthalates as defoliants in which aqueous solutions were pipetted onto the top surfaces of primary leaf blades of young bean plants showed that these compounds were translocated from the points of application, to both foliar abscission zones, i.e., to the laminar zone near the apex of the petiole and to the nodal zone at the junction of petiole and second node. In such applications, as a rule, laminar abscission occurs first, followed in a day to several days by nodal abscission.

Applications to demonstrate that the 3,6-endoxohydrophthalates can be translocated were conducted by applying Carbowax 1500 or lanolin pastes of 3321, 3441, and 3504 on portions of the stem beneath the primary leaves. In Table 14, the results of one such application, in this case with 3321, give clear-cut evidence that this chemical was absorbed through the epidermal layers at such localized areas of applications, then was taken into the vascular system and translocated to other remote plant tissues. It will be noted that applications to the hypocotyls and to the first internodes induced both defoliation and inhibition of trifoliate shoot development. The method of application was to smear a small dab in a narrow ring about the particular part of the stem by means of a toothpick.

Table 14

Effects of localized applications of 3321 in Carbowax 1500 paste on young bean plants after 6 days.

Application area	Physiological Effects	
	Abscission	Inhibition of trifoliate shoot development
Centers of hypocotyls	4 plants, both leaves abscissed	All trifoliate shoots destroyed
Centers of first internodes	5 plants, both leaves abscissed	first trifoliate leaves small to medium
Controls (treated with Carbowax 1500 alone)	None	first trifoliate leaves large; 2nd trifoliate leaves small

Note: eight plants were used for each treatment.

Root Absorption Tests.

Applications were conducted in which exposed rootlets were immersed in various concentrations of aqueous solutions of 3321, 3441, and 3504. The experimental procedure was to select such young bean plants grown in 3-inch pots as had terminal portions of roots extending through the small hole in the bottom of the pots. The soil about the exposed roots was washed carefully as were the bottoms of the pots before immersing the roots. Two cc. of each solution was pipetted into small glass dishes before immersion of roots and the liquid left at various periods after immersion was measured by pipetting. The amount of the solution taken up by the roots was thus determined. Data from a number of applications clearly show that relatively small amounts of these chemicals are translocated upward from the terminal portions of some exposed roots to induce defoliation and inhibition of trifoliate shoot development.

Stem Injection Experiments.

When aqueous solutions of the 3,6-endoxohydrophthalates are injected in very small amounts into the hypocotyls of bean plants, defoliation and inhibition of trifoliate shoot development result. These experiments give confirming evidence that these chemicals can be translocated.

Pharmacology of Compounds

When new agricultural chemicals are introduced into commercial practice, it is necessary that there is sufficient knowledge of their toxicological properties to assure safety and for adequate precautionary measures to be exercised in their handling. Toxicity studies on these particular chemicals have been carried out primarily by Dr. Heinrich Brieger and associates at Jefferson Medical College, Philadelphia, Pennsylvania. We are indebted to them for most of the toxicity data given in this section.

The single dose oral toxicity (LD_{50}) in rats, the effects on the eyes of rabbits and on the skin of humans have been investigated at Jefferson Medical College. Effects of these materials on the skin have been observed also at Sharples Wyandotte laboratories.

The LD_{50} for several of the 3,6-endoxohydrophthalates and salts are compared in Table 14 with corresponding values of a number of currently used insecticides. The LD_{50} of these insecticides were taken from a paper by Dr. Arnold J. Lehman, Chief of the Division of Pharmacology, U. S. Food and Drug Administration[d]. Inspection of Table 14 shows that 3321, 3441, 3504 and 3740 are moderately toxic materials but much less so than such insecticides as tetraethyl pyrophosphate, hexaethyltetraphosphate, parathion and nicotine. They are also considerably less toxic than toxaphene (chlorinated camphene) and rotenone. These 3,6-endoxohydrophthalates fall into approximately the same group as benzene hexachloride and DDT.

Standard patch tests have been run with several of the 3,6-endoxohydrophthalates and salts, but unfortunately, the bis(triethylammonium) salt has not been examined. In these tests, dilute solutions of these materials were held in contact with the skin surface of the upper arm for a period of up to 48 hours. 3321 as solid substance has a strongly irritating effect on the human skin; a 0.1 percent solution in water showed a minimal irritating effect in 4 percent of the men examined. 3441 as solid substance is a rather strong primary skin irritant. 3504 in 1 percent and 4 percent solutions in water produced a light to moderate irritation of the skin.

All of the 3,6-endoxohydrophthalic acids irritated the eyes of rabbits, but dilute solutions of 3504 are in general less irritating than dilute solutions of the acids. First aid treatment in case of contact with the eyes is immediate and thorough washing with copious amounts of water. It is suggested at present that tight-fitting goggles be worn whenever solutions of these materials are handled or sprayed.

Table 15

Single dose (oral) LD_{50} of several agricultural chemicals (rats)

	mg./kg.
Nicotine	10
TEP (Tetraethylpyrophosphate)	2.0
Parathion	3.5
HETP (Hexaethyltetraphosphate)	7.0
Chlorinated Camphene	60
Rotenone	60
GBH (Gamma isomer of benzene hexachloride)	125
3321	410
3441	160
3504	120

Summary

1. The 3,6-endoxohydrophthalates have been found to constitute a group of compounds which show striking plant response effects. Among this group of compounds are 3,6-endoxotetrahydrophthalic acid, its anhydride, and its salts, and 3,6-endoxohexahydrophthalic acid, its anhydride, and its salts.

2. This new group of plant response chemicals gave excellent and commercially feasible defoliation when applied to the top vegetation of a large number of plants. It also has been shown that it is possible to induce defoliation by injecting aqueous solutions of these compounds into the stem or by immersing exposed rootlets into such solutions.

3. This new group of plant response compounds shows striking herbicidal properties when applied to the top vegetation, when used as pre-emergence treatment for many plants, or when injected. They are effective at extremely low dosages per acre. Some evidence indicates that these compounds are hormonal in action. These materials are particularly effective against grasses. The resistance of certain economic crops to harmful action by them indicates their use as selective weed killers.

Literature Cited

(a) J. S. Morris and W. R. Cowley, "Cotton defoliation tests in the Lower Rio Grande Valley", Progress Report 1179, Texas Agricultural Experiment Station, August 16, 1949.

(b) Minutes of the Eighth Annual Western Weed Control Conference, p. 25, Feb. 26-27, 1946.

(c) Daniel Ready and Virginia Q. Grant, "A rapid sensitive method for determination of low concentrations of 2,4-D in aqueous solution", Bot. Gaz. 109, 1, 39-44, Sept. 1947.

(d) Arnold J. Lehman, "The toxicology of the newer agricultural chemicals", Assoc. Food and Drug Officials U. S., Quart. Bull. 12, 82-89, 1948.

Pentachlorophenol as a Herbicide

L. V. Sherwood[1]

The paper on pentachlorophenol presented last year before this conference served to outline the most common methods of using this material and its derivatives as herbicides, and touched briefly upon a number of situations in which this compound has utility. (1) This present paper is intended to explain in more detail just how pentachlorophenol has proved of value in a variety of applications.

In the herbicide field, pentachlorophenol can be adapted to perform a number of functions. These include not only the control of all non-woody vegetation, but also selective weed control in certain crops, defoliation or leaf drying, vine killing, and crop pruning. Specific examples of situations in which pentachlorophenol has proven its value in these functions will be cited.

Oil alone has long been used to control unwanted non-woody vegetation along railroad right-of-ways, ditchbanks, tank farms, substations, fire lanes, orchards and vineyards. Railroads alone have used tremendous quantities of this vital commodity annually for weed control along their tracks. Extensive large scale tests along railroads this past season have demonstrated that by fortifying the oil with penta, equivalent weed control can be obtained at a lower cost while using only 1/5 as much oil as previously. Where 250 gallons of oil were previously used per mile of right-of-way, 50 gallons of this same oil, containing 33 pounds of pentachlorophenol were applied emulsified in 200 gallons of water. This more economical mixture controlled weeds just as effectively as the original oil treatment.

Although pentachlorophenol and its derivatives exhibit a toxic effect on all vegetation which they contact, these materials can be used to selectively kill weeds in certain crops through proper application procedures. Probably the oldest method of this type has been the use of sodium pentachlorophenate (and more recently pentachlorophenol) in sugar cane, where knapsack sprayers are used to apply the herbicide to the weeds only. Around 20 gallons per acre of a spray containing 2-3 lbs. pentachlorophenol in five gallons

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

of oil are applied, using low volume nozzles on the knapsack booms. By treating weeds when they are small, 3-4 such applications are all that is necessary to close in the cane. Using knapsacks instead of the hoe, laborers are able to weed 4-10 times as many acres.

Another method of obtaining selectivity is to use these chemicals as a pre-emergence spray. Successful pre-emergence tests have been made in crops such as potatoes, corn, sugar beets, legumes, and curcubits. Ten to 30 lbs. per acre of sodium pentachlorophenate dissolved in water may be used, or 5 to 10 gallons of a 10% oil solution of pentachlorophenol may be applied per acre in enough water to give uniform coverage.

Established alfalfa fields may also be weeded either early in the spring when growth is just starting or between cuttings. The alfalfa quickly recovers from the effects of the treatment.

Proper concentrations of the sodium salt in water have been used to remove weeds from growing onions, and certain species such as chickweed from lawns. Penta has also proven its utility in orchards, vineyards, and nurseries, where it may safely be used to remove all herbaceous vegetation without injury to the woody crop plants.

Defoliation or leaf drying experiments have proved to be of definite value in harvesting soy beans. Fall applications of pentachlorophenol in combination with 2,4-D not only permitted earlier combining while most of the crop was still upright and more beans could be recovered, but made harvesting easier and faster by drying or removing the weeds which normally would clog the combine. In addition, market dockage of the beans due to the presence of weed seeds was reduced or eliminated. In one case, treatment of a weedy soy bean field approximately doubled the anticipated yield with no dockage. Tests were conducted this year in California to determine if penta in oil could be used to dry the foliage of milo sufficiently to permit earlier harvest, and thus insure against the danger of a premature rainy season. Airplane applications were made, and the treatment permitted the grower to harvest his milo sooner than otherwise possible. This procedure may also prove of value in corn harvesting operations. Other experiments have already shown the value of pentachlorophenol as an efficient potato vine killer.

Another West Coast experiment of interest here in the Northeast involved the use of penta as a combined herbicide and pruning agent in the cultivation of hops. Four treatments were made at monthly intervals, with no mechanical cultivation after emergence of the crops. The first spray was broadcast over weeds and hops alike to control weeds and burn back the hop sprouts, so that uniform shoots would result. Not only was this successful, but the burned-back hops returned with more vigor, were ready to train to strings and ready to harvest ten days to two weeks earlier than those grown normally. The second, third, and fourth sprayings served a double purpose in that they replaced hand suckering operations at the same time weeds were controlled. By using penta, mechanical cultivation was eliminated, an earlier and more vigorous crop resulted, and no hand pruning or cleaning of crowns was necessary.

The applications mentioned above are concrete examples of situations in which the use of pentachlorophenol and its sodium salt have already proven to be of value. They serve to point the way toward experiments in related fields, such as cotton defoliation, pre-harvest leaf drying of corn, sugar cane, rice, and other crops, as well as toward other methods of controlling the environment and response of plants to suit man's need.

Literature Cited

(1) Sherwood, L. V., "Progress in the Herbicidal Applications of Pentachlorophenol", Proceedings of the Northeastern States Weed Control Conference, P. 196-200, 1949.

Do Sprayers Give Uniform Coverage?

C. W. Terry[1]

The first part of this paper deals with special test equipment that was built and used at Cornell to assist in obtaining better knowledge and control of application rates.

The first apparatus described is that which was used for checking nozzle discharge. See Figure 1. It was patterned after the ones used at other ex-

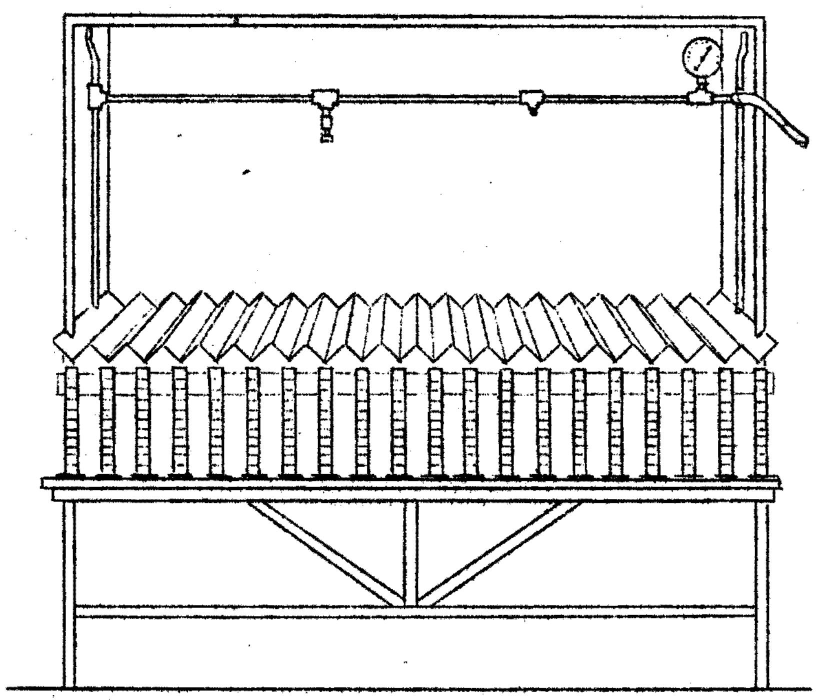

Figure 1

periment stations. A few refinements were added to speed up the test work.

The hood was made of an angle iron frame with galvanized sheet steel lining. The corrugated bottom was made with 3 inch spacing and with comparatively sharp corners rather than usual round corrugations of metal roofing.

The pipe which supported and supplied the nozzle or nozzles was adjustable for height.

The trough which caught the total discharge, and the graduates for catching the flow from each corrugation were mounted on sliding supports. The whole mechanism could be moved in and out by a lever on either end. All

[1]Professor of Agricultural Engineering, N. Y. State College of Agriculture, Ithaca, New York.

graduates could be emptied into the trough simultaneously by lifting up on their supporting rack.

The pump, with its motor and variable speed drive, was mounted in the base of the frame. Pressure was controlled by varying pump speed and by adjusting the built-in relief valve on the bronze gear pump.

The shutoff valve and pressure gage were located in the hood at the end of the boom section.

Tests for total discharge were made at each of four different pressures. Curves of pressure vs. discharge were plotted on log graph paper. These were straight lines and made interpolation or extrapolation of data very easy.

Tests for spray pattern were made by catching the discharge in the 100 c.c. graduates at each pressure. The readings of the graduates were plotted directly on cross section paper.

Prior to each test the pressure was adjusted and the liquid was allowed to recirculate until steady flow was attained. For the discharge quantity tests, time required for a certain volume of discharge (depending on the size of the nozzle opening) was taken with a stop watch. For the pattern tests the time was not important but was recorded. Discharge into the graduates was allowed to continue until one or more were nearly full.

The spray pattern was also observed with a stroboscopic light and photographs were made to determine relative drop size and to help analyze the reason for the spray pattern being what it was.

In the testing of nozzles for pattern with the apparatus described above the discharge for each 3 inches of width was caught by one of the graduates. The number of c.c.'s in each was plotted on ordinary cross section paper. The actual curves were quite irregular in most cases.

The following is a discussion of hypothetical cases together with the effects that would result in case such nozzle discharge was obtained. Remember that the charts do not illustrate a picture of the flow but represent graphically the quantity that might be discharged per unit of width of area being covered by the hypothetical nozzles. If a nozzle gives uniform coverage for its full width or diameter, the nozzle spacing and the boom height will have to be calculated and maintained accurately. Any overlapping will result in doubling the amount of spray for that section. See Figure 2.

If the nozzles give a triangular coverage pattern, heavy in the center and tapering off at the edges, uniform coverage will be attained only when the boom height was correctly maintained and the surface sprayed is smooth and flat. However, slight variations would not be serious in this case. See Figure 3.

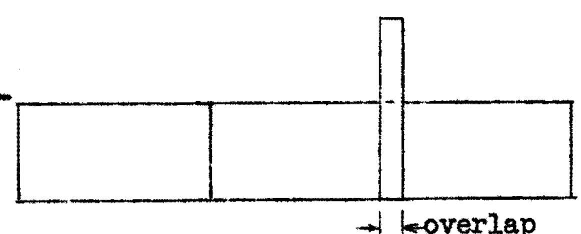

Figure 2

Nozzles that combine the characteristics of these two, illustrated in Figure 4, would give the nearest approach to uniform coverage in actual operation.

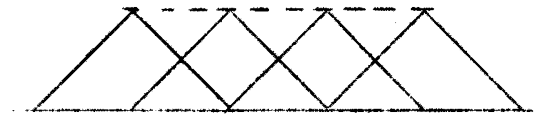

Figure 3

Nozzles that give patterns like those in Figure 5 give more uniform coverage than those with patterns like Figure 6.

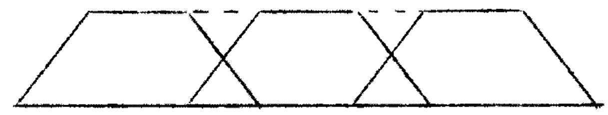

Figure 4

In some of the nozzles tested, the pattern was distorted like that in Figure 7, due to the fact that the breakup of the liquid was not uniform. Any overlap with these nozzles will give a badly distorted pattern.

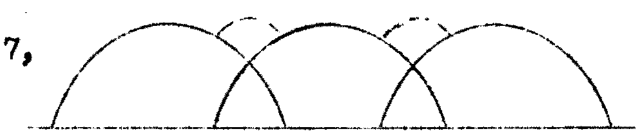

Figure 5

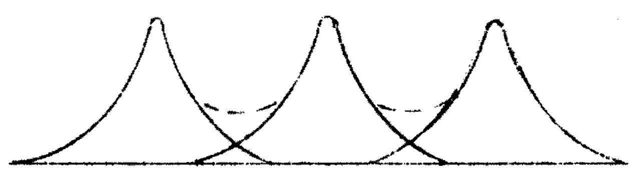

Figure 6

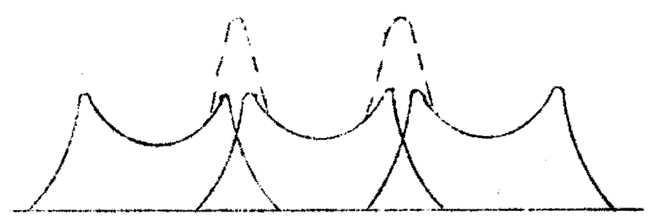

Figure 7

The discussion above is based on the assumption that the nozzle discharge remains the same for different conditions of operation. However, this is not often the case. The effect of even a slight wind is to distort the pattern. If the wind is steady and if the spray droplets are of uniform size the coverage will be nearly as good in a light wind as with a dead calm. But with droplets of variable size and with a gusty wind the pattern is badly distorted.

A speedometer was developed, mainly for turf work. It was built from standard automobile speedometer parts, a wheelbarrow wheel, and a chain and sprocket drive.

A large (80 tooth) sprocket was mounted on the wheel and a small (12 tooth) sprocket on the shaft of a speedometer drive mechanism which was removed from an automobile (at the junk yard). The parts were mounted in a fork which was supported by a hinge pin from a frame attached to the tractor. The sprockets were chosen to give a ratio that would make the speedometer indicate ten times the actual ground speed. Also, the odometer read hundreths, rather than tenths of a mile. Calibration was accomplished by timing with a stop watch, over an accurately measured course at each of several speeds.

This outfit was later used on a hand operated rig for plot work. It was very satisfactory in both cases.

Some factors that are commonly neglected in considering spray patterns are: (1) Falling bodies that have horizontal velocity components follow approximate parabolic paths; not straight lines. (2) Velocity of droplets decreases rapidly a short distance from the nozzle. (3) Different size drops don't have the same terminal velocities and therefore drift at different rates.

The size of pipe used for weed control work is seldom of great importance. With the low discharge rate friction loss in the lines is small and therefore is not apt to affect the spray pattern adversely. Only where a separate supporting structure is used to carry small tubing is there likely to be chance of trouble from this source in low volume spray work.

Height of the nozzles above the ground and nozzle spacing on the boom are closely related. For an angle of 60° to 70° height and spacing are approximately equal for 30% overlap. This seems to be about right for the nozzles most commonly used. In order to have orifice sizes that are large enough to prevent frequent clogging the spacing and therefore the height above the ground must not be too small. Fifteen to twenty inches seems to work satisfactorily for a large part of the work. When it is desirable to get the boom lower the nozzles may discharge at an angle, toward the rear.

Nozzle discharge varies with the square root of the pressure. If the correct nozzle size has been chosen for the particular job, minor fluctuations of pressure have negligible effect on the amount of spray material discharged by the nozzles. If a reliable pressure regulator is used, little attention is necessary. Of course, there should be a gage in the system and the correct reading should be familiar to the operator so that he may recognize when clogging, lack of materials, or pump trouble has occurred.

Speed of travel is important since with a constant discharge rate the number of gallons per acre is directly proportional to the speed. Tractors are not equipped with speedometers and governor settings do not remain constant, therefore, frequent check of speed is important for accurate control of application rate.

If careful attention is paid to the above mechanical details, and if the spraying outfit is kept clean, good results will depend more on the chemicals used and on factors that are expected to give control.

Physiological Studies of the Toxicity of 2,4-D#

Glenn E. Davis and Ora Smith*

The purpose of this paper is to present the results of some investigations which were particularly concerned with the relation between the toxicity of 2,4-D and carbohydrates.

METHODS

The Red Kidney bean was used as the test plant in all of the experiments. Treatments were applied in the seedling stage when the primary leaves had almost fully expanded and before the growth of the second internode had exceeded one centimeter in length.

Prior to planting the seeds were selected for uniformity and every effort was made to obtain uniform plants for each experiment.

A water solution of the triethanolamine salt of 2,4-D was used throughout the experiments. The stock solution contained 40 per cent equivalent of the 2,4-D acid and statements of concentration refer to parts per million of the acid. No carriers or spreaders were used.

The solutions were applied by dipping one of the primary leaves into the proper concentration in such a manner that all of the leaf blade was momentarily in contact with the solution. Other methods of treating were employed in special cases. These are described in the text.

RESULTS

Results of preliminary experiments in which the primary leaf was darkened and treated led to conclusions also held by others. Shading or darkening of the whole plant or treated portions thereof effectively prevented or reduced toxicity. It appeared that the lack of toxicity was due to failure of absorption and/or translocation in the absence of photosynthates.

THE EFFECT OF TREATING BEAN SEEDLINGS GROWN UNDER DIFFERENT DAY LENGTHS

In this experiment plants were grown in the greenhouse under day lengths of four, six, eight, ten and twelve hours and normal day. Day lengths were varied from normal day by use of dark cages and with a framework covered with black cloth. The average temperature in the greenhouse was 84° F. Ten uniform plants were selected for each treatment. They were grown in four inch clay pots in ordinary compost soil.

#Paper No. 327. Department of Vegetable Crops, Cornell University.

*Captain United States Air Force and Professor of Vegetable Crops, respectively.

Thirteen days after planting, a solution of 200 ppm 2,4-D was applied to one of the primary leaves by the dip method. Within each day-length group one lot of plants was treated at the beginning of the light period, one lot at the end of the light period and one lot was not treated. Samples for carbohydrate analysis were taken from each day-length group at the time of treatment with the 2,4-D. The samples were divided into two fractions consisting of leaf tissue and stem tissue.

Ten days after treating, fresh weight measurements were made of the top growth above the primary leaves as a measure of toxicity.

Table 1. Mean weight of shoot growth per plant ten days after treating.

Day Length	Time of Treatment A. M.	P. M.		Mean*	Untreated
	gms.	gms.	:	gms.	gms.
4 hrs.	1.30	1.68	:	1.49	1.6
6 "	1.07	1.46	:	1.26	1.9
8 "	1.37	1.50	:	1.43	1.4
10 "	1.07	1.39	:	1.23	1.8
12 "	.98	1.17	:	1.07	2.0
Normal	.58	.64	:	.61	2.0
Mean**	1.06	1.30	:		
*L.S.D. at 1% -	.15	**L.S.D. at 1% -		.19	
5% -	.11	5% -		.15	

Analysis of the shoot growth data showed a greater toxicity resulting from treatment at the beginning of the day period (Table 1). This difference became less as the day length increased. Toxicity from the treatment was greatest under those day lengths which brought about the highest yield of top growth in the untreated plants.

In general, as the day length increased there was also an increase in total sugar and starch content (Table 2). With an increase in total sugar and starch content there was also increased toxicity.

With regard to the greater toxicity obtained from treatment at the beginning of the light period, at which time carbohydrates were low, it would appear that the carbohydrate content at the instant of treatment was not necessarily a corollary of the toxicity following treatment. Apparently, the carbohydrate content during the absorption period following treatment is more a factor than that which exists at time of treatment. This could very easily be brought about by the lag in abosrption of the 2,4-D which has been shown to be as much as six hours or more.

THE EFFECT OF A SINGLE SHORT LIGHT EXPOSURE PERIOD FOLLOWING TREATMENT AND A PERIOD OF STARVATION. Sufficient seeds of Red Kidney bean were planted on October 29, 1948, to allow for a final selection of 20 uniform plants per treatment. After 40 hours exposure to darkness all plants were treated by dipping one of the primary leaves into 100 ppm 2,4-D. Subsequent to this treatment all plants were maintained as shown in Table 3. Twenty-four hours later all plants exhibiting more than a 30° curvature of the first internode were counted.

Table 2. Total Sugar and Starch Present in Stem and Leaf Tissue at the Time of Treatment. Expressed as Milligrams Glucose per 25 Grams Fresh Weight

	Leaf Tissue				Stem Tissue			
	Total Sugar		Starch		Total Sugar		Starch	
Day length	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
4 hrs.	7.5	24.5	5.5	27.0	5.0	18.0	0.5	19.0
6 hrs.	5.5	27.0	2.5	30.5	12.5	26.0	2.0	20.0
8 hrs.	11.0	27.0	3.5	40.0	20.0	30.0	0.5	24.0
10 hrs.	12.5	33.6	14.5	50.4	21.5	32.2	1.5	33.6
12 hrs.	16.5	27.0	22.5	45.0	30.0	36.0	0.5	31.5
Normal	17.0	30.5	10.0	46.0	28.5	36.0	6.5	33.5

The plants were observed for four days with no change in the above data. It is apparent (Table 3) that a light exposure of about three hours was sufficient to induce rather severe curvature. Considering that the day was very dull with light measuring only 125 f.c., it was interesting that such a short exposure period would induce a toxic response of a telemorphic nature as a result of the 2,4-D treatment on starved plants.

Table 3. The Number of Plants, out of 20, with More Than 30° Curvature in the First Internode at 24 Hours Following Treatment

Light Treatment	Treated	Not Treated
Held in dark	0	0
Exposed to light for one hour	0	0
" " " " three hours	18	0
" " " " six hours	20	0
" " " continuously (normal)	20	0

Another experiment was conducted with the hope of obtaining a higher natural light intensity, and also with the intent of using a better range of light exposure periods. Ten plants were used per treatment as shown in Table 4. Fortunately, the day selected for the light exposure period was one with a hazy to bright sun and the intensity measured from 2000 to 2500 f.c. during the first hour of exposure. The temperature in the greenhouse during the light exposure was 80° F.

The data (Table 4) indicate a response similar to that of the previous experiment. Toxicity from 2,4-D treatment was noted after one hour exposure to light of considerably higher intensity than before. In comparing the two sets of data it is apparent that the duration of light exposure which was necessary to induce toxicity was a function of light intensity. Furthermore, one can be reasonably certain that photosynthetic activity would increase as the light intensity increased under the conditions of the experiment so that the final deduction would be that toxicity symptoms were a function of the photosynthates which were manufactured during the light exposure period.

Table 4. The Number of Plants Showing More than 30° Curvature in the First Internode at 24 Hours Following Treatment

Light Treatment	Treated	Not Treated
Held in dark	0	0
Exposed to light for 15 minutes	0	0
" " " " 30 "	0	0
" " " " one hour	8	0
" " " " two hours	10	0
" " " continuously	10	0

THE EFFECT OF EXTERNAL APPLICATIONS OF MIXTURES OF CARBOHYDRATES AND 2,4-D TO STARVED PLANTS. Previous experiments showed a relationship between toxicity of 2,4-D and the presence of carbohydrates in the plants. The question arose as to whether toxicity could be brought about in starved plants if carbohydrates were added externally to the plant in association with 2,4-D.

This experiment was conducted during the month of November. The plants were grown to primary leaf stage in the greenhouse where the temperature ranged from 65-75° F. During the treatment and subsequent growth stage the plants were held in a dark room where the temperature ranged from 75 to 80° F. Twelve days after planting, 100 carefully selected plants were moved into the dark room. After 36 hours the plants were prepared for treatment. The concentration of 2,4-D was 50 ppm; the concentration of carbohydrate was 0.5 M.

Application of the solution was made by placing one of the primary leaves in a 15 ml vial containing 10 ml of solution. Measurements of shoot elongation were made at five successive 24 hour intervals (Table 5).

Table 5. Mean Length (cm) of Shoot Growth for Five Successive 24 Hour Intervals.

Time after Treatment	24 hours	48 hours	72 hours	96 hours	120 hours
Water	.95	1.08	1.14	1.22	1.25
Water + 2,4-D	1.49	1.73	1.94	1.99	2.00
Sucrose	1.70	3.37	5.37	6.35	6.64
Sucrose + 2,4-D	1.74	1.99	2.10	2.19	2.30
Maltose	1.23	1.67	2.32	2.85	3.00
Maltose + 2,4-D	1.50	1.99	2.10	2.21	2.23
Starch	1.10	1.36	1.60	1.70	1.74
Starch + 2,4-D	1.06	1.24	1.34	1.38	1.45
Levulose	1.39	1.87	2.92	3.85	4.37
Levulose + 2,4-D	1.49	1.77	1.90	1.93	1.94

From the standpoint of lethal effect, mixtures of sucrose, maltose, and levulose, respectively, with 2,4-D were the most potent (Table 6). Sucrose, maltose, and levulose used alone were very stimulating as shown by shoot elongation of one to two centimeters per 24 hour period. When the sugars and 2,4-D were mixed together, growth ceased accompanied by epinasty and necrosis in some cases.

Table 6. Number of Dead Terminal Shoots Five Days after Treatment. Ten Plants per Treatment

Treatment	Number of Dead Shoots	Treatment	Number of Dead Shoots
2,4-D alone	0	Levulose alone	0
Water alone	0	Sucrose plus 2,4-D	9
Sucrose alone	0	Maltose plus 2,4-D	7
Maltose alone	0	Starch plus 2,4-D	0
Starch alone	0	Levulose plus 2,4-D	5

A second experiment was performed in which the purpose was identical to that described above with only slight variation in procedure. In the first place, the carbohydrate concentration was lowered to 0.2 M and the 2,4-D concentration raised to 100 ppm. Secondly, dextrose and inulin were added to the list of carbohydrates.

After 48 hours in the dark, the treatments were applied in the same manner as described in the preceding experiment.

Table 7. Mean Length (cm) of Shoot Growth for Three Successive 24 Hour Intervals

	Time after Treatment		
	24 hours	48 hours	72 hours
Water	.39	.40	.48
Water plus 2,4-D	.37	.42	.49
Sucrose	.55	1.30	2.87
Sucrose plus 2,4-D	.65	.74	.78
Maltose	.47	1.00	2.03
Maltose plus 2,4-D	.54	.60	.65
Starch	.42	.43	.52
Starch plus 2,4-D	.51	.55	.57
Levulose	.67	1.22	2.37
Levulose plus 2,4-D	.42	.47	.54
Dextrose	.50	1.00	1.69
Dextrose plus 2,4-D	.49	.55	.56
Inulin	.39	.43	.50
Inulin plus 2,4-D	.42	.45	.51

The data (Tables 7 and 8) support the same conclusions which can be drawn from the previous experiment (Tables 5 and 6). Although concentrations of carbohydrates and 2,4-D differed between the two tests the results were so similar that comments for both may be made at the same time. 2,4-D alone affected the plants no more than did water alone, but when mixed with sugar solution, especially sucrose, there was marked toxicity leading to death of the plant in most cases. Mixtures of maltose, levulose, dextrose, and even starch with 2,4-D were also lethal to some extent. It is suggested that the starch might have contained impurities which would account for the effects obtained.

In the dark, the plant absorbed sugars through the leaf and utilized them in metabolism as shown by the rapid growth (Tables 5 and 7). Evidently, 2,4-D alone did not enter the plant under the same conditions but when mixed with sugar solutions the beneficial effects of the sugar were nullified, 2,4-D also entered the plant, and serious toxicity resulted.

Table 8. Number of Dead Terminal Shoots 10 Days after Treatment. Fourteen Plants per Treatment

Treatment	Number of Dead Shoots	Treatment	Number of Dead Shoots
2,4-D alone	0	Inulin alone	0
Water alone	0	Sucrose plus 2,4-D	14
Sucrose alone	0	Maltose plus 2,4-D	6
Maltose alone	0	Starch plus 2,4-D	5
Starch alone	0	Levulose plus 2,4-D	4
Levulose alone	0	Dextrose plus 2,4-D	5
Dextrose alone	0	Inulin plus 2,4-D	0

2,4-D AND SUCROSE SUPPLIED AS SEPARATE SOLUTIONS THROUGH OPPOSITE PRIMARY LEAVES, AND THROUGH A CUT SLIVER IN THE HYPOCOTYL OF STARVED PLANTS. Bean seedlings were grown in the greenhouse where the average temperature was 65° F. At the proper stage of growth they were transferred to the dark room, and after 24 hours in the dark they were treated as follows:

1. One primary leaf dipped in a vial of 2,4-D solution (100 ppm); sucrose (0.5 M) supplied through a cut sliver of the hypocotyl of the same plant.

2. One primary leaf dipped in a vial of sucrose solution; 2,4-D supplied through a cut sliver of the hypocotyl.

3. No treatment of the primary leaf; sucrose supplied through the hypocotyl.

4. No treatment of the primary leaf; 2,4-D supplied through the hypocotyl.

Solutions were fed through the hypocotyl by carefully slitting the hypocotyl upwards with a razor blade and placing the vial in such a position that the sliver dipped into the solution.

The plants that received 2,4-D through the primary leaf and sucrose through the hypocotyl were not visibly injured after four days. However, at eleven days shoot growth was retarded as compared with plants that received only sucrose through the hypocotyl (Table 9). This indicated that if sucrose is added to the starved plant via a sliver of the hypocotyl 2,4-D may then enter through the intact primary leaf and retard growth of the second internode. This is further evidence of the positive relationship between sugars within the plant or applied externally, and the mechanism of absorption and/or translocation of the 2,4-D.

All plants that received 2,4-D through the sliver of hypocotyl were dead within four days. Sucrose, simultaneously fed through a primary leaf, did not alter the response.

Table 9. The Length of Shoot Growth (cm) of Five Plants 11 Days After Treatment

Treatment	Plant Number					
	1	2	3	4	5	Mean
1	1.3	0.9	1.3	0.6	0.8	1.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	2.8	1.7	1.3	3.2	6.3	3.0
4	0.0	0.0	0.0	0.0	0.0	0.0

In another experiment bean seedlings were grown in the greenhouse until treatment stage when they were transferred to the dark room. After 24 hours the plants were divided into seven lots of 10 plants each and the following treatments applied:

1. One primary leaf dipped in aqueous solution of 2,4-D (100 ppm).

2. One primary leaf dipped in aqueous solution of 2,4-D; the opposite leaf dipped in sucrose solution (.2 M).

3. One primary leaf dipped in a mixture of 2,4-D and sucrose mixed in aqueous solution.

4. 2,4-D applied through a sliver of the hypocotyl.

5. One primary leaf with one centimeter of the leaf blade excised, then dipped in aqueous solution of 2,4-D.

6. One primary leaf blade excised at the base of the midrib; the cut end of the peticle then dipped in aqueous solution of 2,4-D.

7. Check plants with no treatment.

2,4-D applied through the hypocotyl (treatment four) killed three plants within 48 hours and all were dead by the third day. One leaf dipped in a mixture of sucrose and 2,4-D (treatment three) again proved lethal and all plants of this treatment were dead by the fifth day. 2,4-D applied through the petiole (treatment six) killed eight plants by the fifth day. The plants under treatment five had some necrosis of the blade and portions of the petiole of the treated leaf, but death of other parts, particularly the growing tip, was not sufficient to class them as dead plants. Table 10 presents the data from which the above observations were drawn.

Table 10. The Number of Dead Plants During Five Days Following Treatment.

Treatment	Number of Dead Plants				
	1st day	2nd day	3rd day	4th day	5th day
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	3	6	10
4	0	3	10	10	10
5	0	0	0	0	0
6	0	0	2	8	8
7	0	0	0	0	0

There was a remarkable elongation of the second internode of plants that had opposite leaves dipped in separate solutions of sucrose and 2,4-D (treatment two). It was apparent that sucrose had entered the plant through one primary leaf but 2,4-D had not entered through the opposite leaf since no toxicity appeared. It is quite possible that there was a failure of lateral movement from one primary leaf to the other resulting in failure of the toxic symptoms usually associated with the carbohydrate-2,4-D mixture.

THE EFFECT ON STARVED PLANTS, OF LOW CONCENTRATIONS OF 2,4-D APPLIED THROUGH A CUT SLIVER OF THE HYPOCOTYL. Previous experiments have shown that starved plants would be killed rapidly if 2,4-D were applied through a cut sliver of the hypocotyl in contrast to no effect whatever if the intact leaves were treated. This experiment was planned to investigate the effect of concentrations of 2,4-D lower than 100 ppm.

Seedling plants for the experiment were grown in the greenhouse and transferred to the dark room for 48 hours. They were then divided into seven lots of ten uniform plants each and prepared for treatment. The six concentrations of 2,4-D were one, 10, 20, 30, 40, and 50 ppm. A treatment of water alone was used as a check. As previously described, the solutions were added to the plant through cut slivers of the hypocotyl dipped into a 15 ml vial.

The first symptoms of toxicity were evident after only 24 hours on those plants receiving more than 20 ppm 2,4-D. The primary leaves of many of the plants were drooping because of the very flaccid condition of the pulvini. The petioles had a distinctly hyaline appearance; some were showing air bubbles dispersed in a watery medium along the central core. There was a peculiar watery breakdown of the tissue at the base of the blade. After 48 hours the watery breakdown appeared in scattered areas throughout the blade.

The first internode and petioles of many of the plants had distinct areas of water-soaked tissue after 48 hours. These areas were more often found in the young second internode. They progressed from the hyaline condition to a water-soaked, dark green appearance, to a final collapse of a segment. These collapsed segments had all the symptoms of having been killed with a steam jet. Eventually, the entire plant wilted down and appeared as if it had been killed by freezing or scalding.

By the third day almost all of the plants receiving more than one ppm were obviously dead, and many, which had earlier symptoms, were drying out. There were no brown areas, epinasty was rare, and in no case was there evidence of proliferated tissue, swelling, or curvature of the internode. As shown by the data in Table 11 killing was rapid in all concentrations, although one ppm was slower as might be expected.

The manner of death of the plants in this experiment suggested an immediate lethal effect on the protoplasm of the plant. Death was not preceded by the usual symptoms reported by previous investigators.

Table 11. The Number of Days Necessary to Kill All the Plants in Each Treatment

	Number of Dead Plants					
Treatment	1st day	2nd day	3rd day	4th day	5th day	6th day
1 ppm	1	0	2	4	7	10
10 ppm	0	4	9	10	-	-
20 ppm	0	4	9	10	-	-
30 ppm	1	7	10	-	-	-
40 ppm	0	6	10	-	-	-
50 ppm	0	7	9	10	-	-
Water	0	0	0	0	0	0

In another experiment the same treatments were applied to plants growing in the greenhouse under normal day and night conditions. These plants were from the same original lot as those described above. Symptoms of toxicity were the same as previously reported by other investigators, i. e., curvature of the internode followed by proliferated tissue and growth cessation of the second internode. The primary leaves were persistently dark green and healthy in appearance and although the plants were abnormal in growth habit they were still alive after 11 days. This is in contrast to the rapid kill of starved plants when treated through a sliver of the hypocotyl.

SUMMARY

1. The carbohydrate content of plants which were held in the dark for 36 hours was sufficiently reduced so that 2,4-D applied to intact leaves was ineffective.

2. Mixtures of sugars, particularly sucrose, and 2,4-D were lethal when applied to a starved plant.

3. Starved plants were killed if 2,4-D was applied through the cut end of a petiole, or if it was applied through a sliver of the hypocotyl. Plants growing in normal day and night and treated through the hypocotyl seemed to resist death and grew abnormally.

4. Failure of toxic symptoms when shaded plants are treated, as reported previously, was probably due to failure of absorption and/or translocation. Instances in which shaded plants were killed more rapidly indicate that the physiological condition of the plant was such that 2,4-D was absorbed and translocated and because of low carbohydrates it was therefore extremely toxic.

5. Respiration was stimulated by treatment of starved plants. The degree of stimulation appears to be correlated somewhat with the length of starvation before treatment.

6. When starved plants were treated through the hypocotyl the manner of death suggests that 2,4-D is strongly toxic to the protoplasm. Semi-permeability appears to be destroyed causing exudation of the cell sap and eventual collapse of the tissue.

Chickweed Control in Strawberries with IPC

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

The common chickweed, Stellaria media (L.) Cyrill, is an annual problem in many strawberry plantings in localized areas in Michigan and in many other states. Further, chickweed grows profusely on a well-drained sandy loam which is the soil type similar to that on which strawberries are frequently grown. Because of its crawling growth habit, chickweed soon spreads between the plants in the row, crowding them. Within a short time (four to six weeks) the weed becomes matted over the entire field making it impractical to eliminate it by manual or cultural means. Consequently, growers are in need of a selective herbicide that can be used safely and effectively to control chickweed and save the strawberry planting for a second and third crop.

Since chickweed is a winter annual, most of the seed germinates in early September in Michigan. The seedlings grow and spread rapidly during the fall and early winter both in the open field and under a straw mulch. By early spring a large number of seeds are produced which remain dormant during the summer and germinate when the conditions are favorable in the fall. Thus, many first- and second-year strawberry plantings are infested with the weed.

Materials and Methods

During the fall of 1947 several herbicides including 2,4-D (2,4-Dichlorophenoxyacetic acid), Dow General (dinitro-ortho-secondary-butylphenol) and IPC (Isopropyl N-phenylcarbamate) were tried at herbicidal concentrations for the control of chickweed in strawberries. The "dinitro" compound was included because it had given promising performance when applied in the fall on annual weeds in strawberries (6), and the 2,4-D because of the resistance of strawberry plants to it (1). Because IPC had exhibited selective properties on grasses and some broad leaved weeds it was also included (2, 4 and 5). It also had been found that IPC killed common chickweed when applied at low concentrations (3 pounds per acre) to a lawn overgrown with the weed (3).

From these preliminary tests in 1947 it was found that IPC controlled chickweed; Dow General "burned" the foliage of both chickweed and strawberry plants; and 2,4-D showed no visual effect on chickweed. In the fall of 1948 the tests were limited to IPC at four concentrations, namely, 5, 10, 15, and 25 pounds per acre and applied at different times (September, October and November). Two locations were chosen in southwestern Michigan where chickweed is a serious weed in many strawberry plantings. The soil type at one location was a Coloma sandy loam and at the other a Plainfield sandy loam. The Robinson variety was grown at one location and the Premier at the other, both plantings having been started the previous spring (1948).

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[1]Horticulture Department, Michigan State College, East Lansing, Michigan.

The technical grade of IPC was diluted with enough talc so that it could be dusted evenly over the strawberry rows. The material was applied at both locations on September 20, October 22 and November 12. At the date of the first application the chickweed was in the 2-leaved stage; at the second it was spreading over the ground; and at the third it was matted in and between the rows. Flowering of the weed began at the second application (October 22). The strawberry plants were vigorous and had numerous runner plants. At the time of the first application, September 20, it is probable that they were still initiating flower buds since that occurs during the month of September and well into October in Michigan.

At both locations the plots consisted of twenty-five feet of row and two rows were used for each treatment. The rows originally were planted four feet apart and at the time of the applications were in a matted row about 18 inches wide. The dust form of IPC was applied with a small hand operated duster. Care was taken to distribute the dust evenly over the entire row where the weed is difficult to remove by hand pulling or hoeing. The check rows were weeded by hand.

Results

Effects on Chickweed: - At the time of the November applications, the chickweed in the plots treated in September were apparently dead at the higher concentrations (10, 15 and 25 pounds per acre). At the lower rate (5 pounds per acre) about 20 per cent of the chickweed was still alive. The chickweed in the treated plots appeared grayish, water-soaked as compared to the green vigorous growth in check rows. The water-soaked appearance was most pronounced on the 2- to 3-inch basal portion of the stem. Many of the leaves were dark green with a leathery appearance, and considerably thicker than leaves from untreated chickweed.

The chickweed treated October 22 had begun likewise to take on a slightly wilted and water-soaked appearance by November 12. On December 15 similar effects on the chickweed were noticed in the November 12 applications at all rates. At that time the weed in the earlier applications had started to turn brown.

The following spring (April 15) all of the chickweed in the 15 and 25 pound applications was dead and in the 5 and 10 pound rates about 80 to 95 per cent was controlled. This held true for all applications (September, October, and November) and for both locations.

Effect on Strawberry Plants: - A slight marginal color change (yellow) of the younger leaves was observed in November on the plants that had been treated in September. This change was most noticeable at the high concentration (25 pounds per acre). This effect was noticed also in the spring on plants treated with the high concentration and at different times the previous fall. Flowering appeared normal and occurred at the same time as the plants in the check rows. From general observations yield also compared favorably to the untreated hand-weeded check rows. No varietal differences were observed as to resistance to the material (IPC).

November 20, two months after the September applications, 20 plants were dug from each treatment and from the check rows and were planted and grown in the greenhouse. At the time of transplanting, the plants were examined carefully for possible injury to the roots or crowns, but no visible effects were noticed. The plants grew normally and fruited in March in the greenhouse. After they had fruited they were dug and examined further. It was noticed that the roots of the plants that had been treated with 25 pounds of IPC per acre were injured as was indicated by the dark color and the formation of a number of secondary roots at the base of the crown (Fig. 1.). The roots of the plants from the other treatments (5, 10 and 15 pounds per acre) appeared normal and vigorous, and in addition the root systems were more extensive and better developed than those of the check plants.

Summary of Results

Four rates of IPC (5, 10, 15 and 25 pounds per acre) were applied at three different times (September, October and November) in 1948 and at two locations to chickweed growing in plantings of Robinson and Premier strawberries.

Satisfactory control of chickweed was obtained at all concentrations and from various times of application. The chickweed at first exhibited a water-soaked appearance at the basal portions of the stem and turned brown and died approximately two months after application.

Apparent yield of fruit from treated plants was equal to that of plants in hand-weeded rows. Some injury to the plants was noticed at the high rate.

The roots of the strawberry plants appeared more vigorous from treated areas (5, 10 and 15 pounds per acre) than those from the check rows. Some injury was noticed on the roots of plants from the higher rate (25 pounds per acre) of application which showed up as darkening of the roots and formation of new roots at the base of the crown.

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CHEMICAL WEED CONTROL IN COFFEE [1]

Ora Smith, Joseph R. Orsenigo, and Milton E. Gertsch[2]

The weed control problem in tropical areas is greatly aggravated by environmental conditions very favorable for plant growth. In many areas at the lower elevations, annual rainfall is frequently greater than one hundred inches per year. Temperatures throughout the year are moderately high. In many regions, and particularly in those with short or poorly defined dry seasons, it is not uncommon for numerous weed species to flower and produce seed in every month of the year. Greatly facilitated plant growth and plant reproduction under these favorable conditions are responsible for the continual battle against weeds. Generally the methods used to attempt to control weeds culturally are ancient and require repeated and vigilant care. These cultural methods are laborious, time-consuming, and expensive. Due to increasing cost of materials, foodstuffs, and labor, many growers are faced with increased agricultural production costs. In several crop growing regions, a labor shortage exists at present.

The aim of chemical weed control is to attain more efficient, more economical, and longer lasting control so that production costs can be lowered and that labor may be released for other less laborious farm operations.

Results of studies to be presented indicate that weeds can be efficiently controlled in economic crops at costs competitive with the cultural methods in use at the present time.

Studies were initiated to determine the possibilities of obtaining by chemical methods practical, efficient, and economical control of weeds for long periods in coffee plantings. The weed population in most coffee fincas (farms) is comprised of many weed families and species; Compositae, Commelinaceae, Convulvulaceae, Cucurbitaceae, Gramineae, Umbelliferae, and others. Their control requires laborious and expensive control measures which are a large part of coffee production costs. The exact cultural methods used vary from region to region and among the individual growers within a region. In Costa Rica where this experimental work was conducted, the control of weeds in coffee plantings is commonly achieved by slashing, by shovelling, or by a combination of these two. Slashing is a practice in which the machete is used to cut

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[1] This project was supported by a grant from the Standard Oil Development Co., Elizabeth, N. J. to the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica, and directed by Ora Smith.

[2] Professor of Vegetable Crops, New York State College of Agriculture, Cornell University, Ithaca, N. Y., and Graduate Assistants, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

all undesired vegetation at or slightly above the ground surface. Plant material so cut is not removed. The operation may be performed two to six or even more times per year depending on the weed growth. Shovelling, a more arduous task, is a process that is complicated by the many ways in which it may be carried out. However, the term implies, in a general sense, the turning over or inverting of the top inch or so of soil and vegetation with a broad-bladed shovel. The plant growth is covered by the soil. Shovelling may be required from one to four times per year depending upon the judgment and preference of the grower and the amount of weed growth in the coffee planting. Other than being an expensive operation, the practice of shovelling may be harmful in its effects on the coffee tree whose feeding roots are mainly superficial and are easily seen exposed after the shovelling operation.

Experiment 1. Only two of the six experiments conducted will be described here. The experimental area was shovelled on July 8, 9 and 10, 1948. The 35 treatments were applied on August 9, 10 and 11, 1948. The size of each plot was 8-1/2 feet by 8-1/2 feet centered on one uniform, bearing coffee tree. There were four replications. Some of the chemicals employed were: pentachlorophenol and its sodium salt, the ammonium and sodium salts of trichloroacetic acid, sodium isopropyl xanthate, and isopropyl phenyl-carbamate. Sinox General, 1 pint per acre, and 2,4-D, butyl ester, 3/4 lb. per acre were used as additional fortifying agents. Water solutions of herbicidal materials were applied at 100 gpa. The same materials were applied in heavy aromatic naphtha (HAN 132) and diesel oil at 25 gpa for low-volume applications. These two oils were used also emulsified at 3 to 10 gpa with 100 gpa carrier volume. When the ground surface was treated with the herbicides, the coffee tree trunk in each plot was also sprayed with the chemicals in an effort to determine the value of the treatments in the control of mosses and lichens growing on the trunks. The rainy season was in progress at the time applications were made. Weed counts were taken on the following dates: September 10, 1948, October 11, 1948, January 26, 1949, March 25, 1949, and June 11, 1949. Weeds were counted in two 2 x 4 feet areas in each plot. Visual evaluations of weed control were made on the following dates: October 24, 1948, December 21, 1948, February 18, 1949, April 19, 1949 and June 19, 1949.

All treatments obtaining a score value equivalent to or greater than that of the check in the October 24, 1948 visual rankings were kept for further testing and observation. The coffee crop was harvested following this evaluation, and on November 12 and 13, 1948, the 20 chemical treatments that were arbitrarily chosen by achieving control equal to or greater than that of the check were retreated. The check was retained for comparison but was not shovelled or culturally treated.

The experiment was formally terminated in June, 1949 at which time several of the treatments were still maintaining weed-free ground surfaces. All treatments maintained until this time had received but two applications of the chemicals. The second application was made 3 months after the first. Nine months after the second application weed free plots were common for many of the treatments; it appeared that no further chemical treatment would be required in the cleanest plots for several months longer.

The five most effective treatments at the time of the termination of the experiment were:

		Amt. per acre
1.	Sodium pentachlorophenate	2 lbs.
	2,4-D, butyl ester	3/4 lb.
	Heavy aromatic naphtha 132	5 gals.
	Emulsifier	1 pt.
	Water	95 gals.
2.	Pentachlorophenol	4 lbs.
	2,4-D, butyl ester	3/4 lb.
	Heavy aromatic naphtha 132	10 gals.
	Diesel oil, commercial	25 gals.
3.	Sodium isopropyl xanthate	10 lbs.
	Heavy aromatic naphtha 132	10 gals.
	Emulsifier	1 pt.
	Water	90 gals.
4.	Sodium trichloroacetate	30 lbs.
	Water	100 gals.
5.	Ammonium trichloroacetate, 70%	1 gal.
	Heavy aromatic naphtha 132	25 gals.

When observed in the first part of August, 1949, these treatments still were strikingly effective in the control of weeds.

This experiment was in progress over a period of 12 months during which time several of the treatments maintained a ground surface relatively free, and in some cases entirely free, of weeds under the cultural conditions of the experiment. Ordinarily, during this one year period, 2 to 4 shovellings would have been required to effectively control weeds in the area of the experiment. It was shown that chemical weed control materials will control weeds with as few as or fewer applications than shovellings. The effective treatments are very inexpensive. The second application of the chemicals controls weeds for longer periods than the first. Presumably, the third and subsequent applications would show that weed control can be easily maintained by repeated applications at successively greater intervals. It is also apparent that the succeeding treatments need not be complete ones over the entire ground surface, but rather "spot-sprayings" wherever weed growth is sufficiently great to require treatment. Low cost treatments found to be effective in this experiment are at such a level as to be directly competitive with the present laborious and time-consuming cultural methods; several of them would cost as low as $5.00 to $6.00 per acre, including the cost of application. Several of the pentachlorophenol-reinforced treatments appear to be promising in the control of mosses, but none was found effective in the control of lichens.

<u>Experiment 2.</u> This experiment was designed and planned to test the efficiency of pre-formulated pentachlorophenol and its sodium salt in the control of weeds in coffee. In Experiment 1, in addition to other weed killing materials, the more effective treatments that were developed utilized pentachlorophenol compounds. These two contact herbicides are inexpensive when compared with other materials. However, the problem of dissolving powdered or granulated solid materials having low-solubility rates is occasionally difficult. It was thought that preparation of these two chemicals dissolved in oil would greatly facilitate their field use. Consequently, several of the chemicals were made up in oil. Different emulsifiers were added to determine if the emulsifying agent altered the effectiveness of the formulation.

The area chosen for this experiment was shovelled in April, 1949, and the chemical treatments applied on May 23 and 24, 1949. There were four replications of the 47 treatments. Each plot was 8-1/2 feet square centered on one mature, bearing coffee tree. Weed growth in the area of this experiment was more advanced at the time of treatment than that of the other experiment. The carrier rate of all treatments was 100 gpa. Pentachlorophenol and its sodium salt were applied at two rates, 2 and 4 lbs. per acre either in water solution or in emulsions of 10 or 15 gpa of commercial diesel oil or 15 gpa of heavy aromatic naphtha 132. Several treatments were in addition reinforced with the butyl ester of 2,4-D at 1 lb. per acre. For comparison, several pentachlorophenol treatments found to be effective in Experiment 1, were compounded from bulk chemical stock and included in the trial. Also, several treatments utilizing Sinox General and Xanthogen disulfide were tested. Ground shade throughout the area of the experiment was very light compared to that of Experiment 1. The pruning of both the coffee trees and the shade trees was similar to normal commercial practice. The rainy season had commenced several weeks prior to the application of the treatments and on each application date, moderate to heavy rains of short duration followed the applications. During the 72-hour period following the spraying of the treatments, precipitation of 4.7" was recorded. Since this rain was so heavy and followed spraying so closely, it is suggested that the rate of weathering of the herbicides was greatly accelerated. Visual evaluations of the treatments were made on June 22, 1949 and July 23, 1949. At the time of these evaluations, many treatments were maintaining excellent, completely weed-free ground surfaces despite the severe weather conditions at the time of application.

Based on the two evaluations, three treatments were found to be markedly-effective. Actually two of the first three treatments were identical with the exception of the emulsifying agent used. The first two treatments reported here are strikingly similar in composition to each other and to the treatments found to be most effective in Experiment 1. They are as follows:

		Amt. per acre
1.	Pentachlorophenol	4 lbs.
	2,4-D, butyl ester	1 lb.
	Heavy aromatic naphtha 132	15 gals.
	Emulsifier	
	Water	85 gals.

		Amt. per acre
2.	Sodium pentachlorophenate	4 lbs.
	2,4-D, butyl ester	1 lb.
	Diesel Oil, commercial	15 gals.
	Emulsifier	
	Water	85 gals.
3.	Sinox General	2 pts.
	2,4-D, butyl ester	1 lb.
	Heavy aromatic naphtha 132	15 gals.
	Water	85 gals.

Also, in this experiment, as has been shown repeatedly, excellent weed control was afforded by the combination of Sinox General and 2,4-D applied in oil emulsion.

Pentachlorophenol and its sodium salt pre-formulated in oil were found to be as effective as similar treatments compounded from bulk chemicals. It is unlikely that the emulsifiers used in this experiment affected weed kill or the efficiency of the treatments. It was markedly demonstrated in this experiment that treatments using 2,4-D added to the pentachlorophenol compounds and applied in oil greatly increased weed control over similar treatments not using 2,4-D.

In the middle of August, 1949, or about 80 days after application, weed control was excellent in the treatments reported and to a slightly lesser extent in several others. Unfortunately, data are available only for this short period. However, it was apparent that the treatments indicated would be effective for several months longer than reported.

Recommendations: As a result of the experiments reported in this paper, the following post-shovelling treatments are recommended for the control of weeds in coffee fincas:

	Treatments	Amount per acre
1.	Sodium pentachlorophenate	4 lbs.
	2,4-D, butyl ester, acid equivalent	1 lb.
	Heavy aromatic naphtha 132	5 gals.
	Emulsifier	1 pt.
	Water	95 gals.
2.	Pentachlorophenol	4 lbs.
	2,4-D, butyl ester, acid equivalent	1 lb.
	Heavy aromatic naphtha 132	10 gals.
	Diesel oil, commercial	25 gals.
3.	Sinox General	2 pts.
	2,4-D, butyl ester, acid equivalent	1 lb.
	Heavy aromatic naphtha 132	10 gals.
	Water	90 gals.

	Treatments	Amount per acre
4.	Sodium isopropyl xanthate	10 lbs.
	Heavy aromatic naphtha 132	10 gals.
	Emulsifier	1 pt.
	Water	90 gals.

The water rates in treatments 1, 3, and 4 may be lowered to 45, 40, and 40 gallons per acre respectively without reducing the herbicidal efficiency of the treatments. Diesel oil, commercial grade, may be substituted for the heavy aromatic naphtha 132 at twice the rate; that is, two gallons of diesel oil can be used in place of every gallon of aromatic naphtha.

Experiments with Potassium Cyanate and Calcium Cyanamid on New Jersey Asparagus, 1949

Stuart B. LeCompte, Jr.[1]

Introduction

Seven experiments with potassium cyanate and calcium cyanamid on Sassafras sandy loam soil in New Jersey during 1949 are described below. Work with potassium cyanate, Tables 1-6, Experiments I to VI, was conducted on seven year-old asparagus beds at the Vegetable Research Farm of Rutgers University, New Brunswick, with records of temperature, rainfall, evaporation, and sunshine. Work with calcium cyanamid, described in Experiment VII, Tables 7-10, was carried out on a commercial scale in Cumberland County and was a cooperative undertaking by Mr. John Johnson of Deerfield, New Jersey, who made his land and crop available for the experiment, the P. J. Ritter Company who agreed to furnish records of asparagus yield and quality, the American Cyanamid Company, who provided the calcium cyanamid, and the Vegetable Crops staff, Department of Horticulture, New Jersey Experiment Station, who agreed to assess the degree of weed control and report measurements made on the crop together with photographs or other documentation.

Equipment and Materials

Data on temperature, rainfall, evaporation, and radiation were obtained as described elsewhere (2) and are given in Table 6. Radiation in gram calories per square centimeter was measured with the same Kipp and Zonen integrating solarimeter used in 1948. This device, a thermopile, is stated by the manufacturer to integrate approximately 9 gram calories of radiant energy per square centimeter per solarimeter unit. Independent calibrations of the solarimeter by Dr. Arthur Quirk, Director, Upper Air Research Laboratory, Physics Department, Rhode Island State College, and by Dr. Robert Withrow, Chief, Division of Radiation and Organisms, Smithsonian Institution of Washington, have shown that an accuracy of three to five per cent was obtained with the solarimeter.

Potassium cyanate was used as an aqueous solution of 1 to 2% strength, that is, 0.5 to 1 lb. KOCN per six gallons of water. Vatsol K. was used as a wetting agent at the rate of 11.3 grams per gallon of water for certain tests with the 2% potassium cyanate. Both potassium cyanate and Vatsol K. were provided by the American Cyanamid Co. The cyanate sprays were applied with a hand sprayer and nozzle provided by Dr. Dale Wolf of Rutgers University. At thirty pounds pressure and four miles per hour, this equipment applied about sixty gallons per acre.

Granular calcium cyanamid was applied at the rate of eight hundred pounds per acre by a lime spreader to Mr. Johnson's asparagus rows, about three feet width across the ridge. With a row spacing of about 4.8 feet, the application was, therefore, five hundred pounds calcium cyanamid per acre, on the basis of the total area of the treated field.

[1]Associate Professor and Associate Research Specialist, Vegetable Crops, Rutgers University, New Jersey Agricultural Experiment Station, New Brunswick, NJ.

Procedure

Random weed counts were made on treated areas with accompanying photographic records. Experiments I, II, III, and V were arranged in 2 x 2 or 4 x 4 Latin Squares, each treatment covering from one to several rows of bed 19 to 39 feet long. Data on asparagus condition in Experiments III, IV, and VI were taken on several rows, each 77.5 feet long.*

Experiment VII with calcium cyanamid dealt with six acres each of treated and untreated area planted to asparagus three and four years old. An 8 mm. Kodachrome motion picture was made of the results on Mr. Johnson's farm ten and thirty-two days after applying the granular cyanamid.

Results

Potassium Cyanate Tests During Asparagus Cutting Season

Experiment I. Asparagus was treated with 2% potassium cyanate solution at 7 a.m. on April 28th by Dr. Dale Wolf. The weather was bright and clear with an air temperature of 56 degrees F. and a light breeze. Small weeds, half inch in height, were visible. On May 7th, spear condition was noted and weeds were counted as shown in Table 1. No tissue destruction was observed on any spears, the untreated spears showing about the same degree of tip crookedness as found in the treated plots. Untreated areas showed about twice the average weed count found on treated areas. At this time, the untreated weeds were about an inch taller than weeds on treated plots.

Experiment II. On May 5th, 2% cyanate was applied to three or four rows of asparagus, beds 39 feet long. Comparable areas were left untreated. The spray was applied between 11:45 and 12:05 with an air temperature of 80 degrees F. Results, taken two days after treatment, are given in Table 2. The weed population, dominantly lambsquarters, mixed with Amaranthus and an irregular scattering of grass and morning glory, was reduced by the treatment to about one-fifth of that on untreated control plots. No damage to the marketable crop was apparent.

Experiment III. On May 6th, sixteen rows of asparagus, each 77.5 feet long, and certain control areas of Experiment II were treated about noon with 2% potassium cyanate and Vatsol K. wetting agent. The air temperature was 84 degrees F. and the weather dry and clear. Heavy damage was noted by 4 p.m. to the thick growth of lambsquarters about three inches tall, scattered grasses about 9 inches tall, and chick weed, clumps about 5 inches wide. Data on spear condition and random weed count about 24 hours after treatment, are given in Table 3. No injury or tissue destruction was found on asparagus spears. The number of abnormal spears, that is, spears with crooked tips, was about the same on treated and untreated asparagus rows, and ranged from about 2 to 4% of the total spear count. Random observations of live weeds on treated plots showed about four-hundredths the population of untreated controlled areas. The leaves of Canada thistle, about 8 inches high, were killed or severely damaged, but the buds and underground stems survived and resumed growth. Lambsquarters or chick weed were killed or severely damaged. Volun-

*Thanks are extended to numerous student assistants and members of the Vegetable Crops Staff who aided execution of the work.

teer asparagus seedlings were apparently unhurt. The effect of the treatment in Experiment III lasted for about a month under the conditions at New Brunswick, but weed control was broken by June 14.

Potassium Cyanate Tests on Asparagus Seedlings

Experiment IV. On the relatively warm, bright days of June 15th, 16th, and 17th at New Brunswick, maximum temperatures 84-86° F., young asparagus seedlings one to two inches tall, in rows 77.5 feet long, infested heavily with rag weed, lambsquarters, amaranthus, and grass, up to five inches high, were sprayed with potassium cyanate, 2% solution plus Vatsol K. wetting agent. The young shoots of the asparagus were killed or damaged. Good weed control was obtained. The underground shoot buds and roots of the asparagus seedlings were apparently unhurt, since these vital portions of the plants were an inch or more under the surface of the soil. New shoots emerged later.

Scattered observations on asparagus seedlings in commercial beds in Bridgeton and Swedesboro, New Jersey, were made at this time, with results described in the foregoing paragraph. Mr. Ernest Burch of the California Packing Company, Swedesboro, and Mr. Collum of the P. J. Ritter Company, Bridgeton, cooperated in this work.

Experiment V. Asparagus seedlings, ranging to about 2 inches in height, were sprayed on July 25th with potassium cyanate 1%, 2%, and 2% plus Vatsol K. wetting agent. Untreated controls and the other treatments were arranged in a 4 x 4 Latin Square, two rows/unit about 19 feet long. The weather was hot, dry, and clear, air temperature 92 to 95 °F, spraying time between 2:30 and 3:55 p.m.; dominant weeds: carpetweed[1], and grass about one inch high. Data on weed count and number of asparagus shoots living at treatment time are given in Table 4. Similar data, nine days after treatment, are shown in Table 5. Under the conditions of the experiment, 1% solution of potassium cyanate was apparently just as effective for weed control as 2% cyanate with or without a wetting agent, and at the same time seemed as harmless on the average, to the asparagus shoots, as the lack of chemical treatment. Weed count was reduced by the treatments to about one-sixth the value noted on control areas.

Weed Control in Asparagus Brush with Potassium Cyanate Plus Wetting Agent

Experiment VI. Heavy applications of potassium cyanate, 2% solution plus Vatsol K. were made on August 1 to 3 on heavy weed growth (dominantly lambsquarters and pigweed) in mature brush, about 560 gallons per acre, at the Vegetable Research Farm, New Brunswick. The weather was warm, dry, and sunny with maximum temperatures 85° F. and minimum temperatures 64-73° F. Cyanate applications exceeded those rates previously reported, (2). Good weed control was obtained and persisted well into September. Some damage to the skin of the stalk bases was observed and occasional killing of the leafy fern of a young shoot was noted. In general, however, the asparagus brush continued to flourish and set seed without apparent ill-effect due to the cyanate treatment, despite the severe drought of 1949.

[1] Mollugo verticillata L. Purslane, morning glory and Amaranthus were also present.

Table 1. Experiment I. Asparagus spear condition and weed count, May 7, 1949, 9 days after spray with water solution 2% potassium cyanate, 60 gal./acre during cutting season, New Brunswick, N. J.

Spear Condition

Plot No.	Treated Spears/20 feet row Total No.	Abnormal* No.	%	Untreated Spears/20 feet row Total No.	Abnormal* No.	%
1	70	7	10	31	0	0
2	17	3	18	46	5	11
3	54	2	4	41	3	7
4	32	3	9	40	5	12
Mean			10			8
Range			4-18			7-12

Random weed count per 50 sq. in.

Plot	Treated** a	Treated** b	Untreated*** a	Untreated*** b
1	47	43	76	111
2	74	105	77	137
3	165	60	310	230
4	112	108	243	260
Mean	89		180	
Range	43 - 165		76 - 310	

* Crooked tips, no tissue destruction observed.

** Dominant: Chenopodium album, 1 inch tall.

*** Dominant: Chenopodium album, 2 inches tall.

Table 2. Experiment II. Weed count in asparagus, May 7, 1949, 2 days after spray with water solution 2% potassium cyanate, 60 gal./acre during cutting season, with notes on spear condition, New Brunswick, N. J.

	Random weed count* per 50 sq. in.					
	Treated			Untreated		
Plot	a	b	c	a	b	c
1	6	22	8	64	50	106
2	7	30	8	82	141	110
3	12	5	4	210	151	156
4	23	11	12	118	83	141
5	48	39	28	109	130	151
6	19	29	8	---	---	---
7	82	50	33	---	---	---
Mean		23			120	
Range		4-82			50-210	

*Lambsquarters (Chenopodium album) dominant, mixed with Amaranthus spp.

Note: 1. No damage to the marketable asparagus crop was apparent.

2. Of thirty-six slender, tagged spears, (ranging in diameter thus: eleven, 0.07" - 0.14"; fourteen, 0.16" - 0.24"; eight, 0.25" - 0.32"; three, 0.36" - 0.43"), on treated plots which were examined for abnormalities, May 7, two (5.6%) appeared injured. The diameters of the two were 0.13 and 0.19 inch. Whether injury was specifically due to the spray was not determined.

Table 3. Experiment III. Asparagus spear condition and weed count, May 7, 1949, one day after spray with water solution 2% potassium cyanate plus Vatsol K, 60 gal./acre during cutting season, New Brunswick, N.J.

Spear condition, 77.5 feet row

Treated				Untreated			
Row* No.	Total Spears No.	Abnormal Spears No.	%	Row No.	Total Spears No.	Abnormal Spears No.	%
13	187	4	2.1	34	185	5	2.7
32	185	4	2.2	35	191	8	4.2

Random weed count per 50 sq. in.

Treated			Untreated		
a	b	c	a	b	c
10	12	2	64	50	106
0	0	3	210	151	156
Mean	5			123	
Range	0-12			50-210	

*Counted from south edge of beds.

Table 4. Experiment V. Asparagus seedling and weed count at time of spraying with potassium cyanate solutions, July 25, 1949, New Brunswick, N. J.

Treatment KOCN	Plot No.	Asparagus Shoots Green-Live No.	No. weeds*/50 in.^{2} Random locations a.	b.	c.	d.
1%	1	36	52	34	22	28
	6	45	58	24	31	23
	11	42	12	15	15	25
	16	25	41	34	36	37
Mean		37	30			
Range		25 - 45	12 - 58			
2%	2	30	27	22	36	28
	5	42	34	37	33	40
	12	41	23	28	23	35
	15	36	28	18	16	30
Mean		37	29			
Range		30 - 42	16 - 37			
2% + Vatsol K	3	23	16	22	13	21
	8	40	21	17	20	15
	9	37	63	60	53	72
	14	42	52	47	24	19
Mean		36	33			
Range		23 - 42	13 - 72			
Untreated	4	38	19	18	20	9
	7	42	13	23	20	15
	10	52	34	40	80	49
	13	23	60	48	54	43
Mean		39	34			
Range		23 - 52	9 - 60			

*Carpetweed (Mollugo verticillata L.), purslane and grass dominant.

Table 5. Experiment V. Effect of potassium cyanate water solution on asparagus seedlings (shoots 2 inches tall) and on mixed weeds 9 days after treatment. August 3, 1949, New Brunswick, N. J.

Treatment KOCN	Plot No.	Asparagus Shoots Green-Live No.	Dead No.	Dead %	No. weeds/50 in.[2] Random locations e.	f.	g.	h.
1%	1	47	0	0	2	6	3	1
	6	64	1	1.6	3	4	6	8
	11	55	2	3.6	5	4	6	5
	16	47	0	0	3	5	3	6
Mean		53		1.3	4			
Range		47 - 64		0 - 3.6	1 - 8			
2%	2	56	5	8.9	5	6	4	4
	5	44	3	6.8	1	0	1	2
	12	44	9	20.4	3	7	1	4
	15	44	4	9.1	4	2	3	3
Mean		47		11.3	3			
Range		44 - 56		6.8 - 20.4	0 - 7			
2% + Vatsol K	3	18	8	44.4	2	1	0	1
	8	66	17	25.8	6	1	4	2
	9	33	16	48.5	4	1	4	4
	14	38	16	42.1	6	2	4	1
Mean		39		40.2	3			
Range		18 - 66		25.8 - 48.5	0 - 6			
Untreated	4	51	0	0	16	16	12	5
	7	50	4	8.0	22	16	14	10
	10	60	0	0	31	36	23	29
	13	28	0	0	42	33	62	63
Mean		47		2.0	27			
Range		28 - 60		0 - 8.0	5 - 63			

Table 6. Data of temperature, rainfall, evaporation, and radiation pertaining to Experiments I-VI, with potassium cyanate on weeds in asparagus, New Brunswick, N.J. 1949. (continued on next page.)

Date	Temperature °F. Max.	Min.	Rain Inches
April			
28	75	51	
29	64	36	
30	73	38	
May			
1	73	48	1.22
2	75	56	+
3	76	58	0.60
4	84	51	
5	88*	58*	
6	91**	66*	
7	80**	56	0.44
8	69	48	
9	73	40	
10	58	54	0.49
11	56	49	
12	65	44	
13	69	46	
14	78	46	
15	67	53	0.24
16	67	50	
17	79	55	
18	82	57	
19	87	61	
20	68	50	0.85
21	65	38	
22	65	49	0.29
23	76	57	0.74
24	78	52	
25	62	41	0.24
26	60	39	0.13
27	64	44	
28	62	48	
29	64	41	
30	69	39	
31	77	49	
June			
1	75	50	
2	78	46	
3	79	45	
4	85	46	
5	87	67	
6	87	59	
7	83	55	
8	72	48	
9	76	47	
10	79	45	
11	85	59	
12	92	63	
13	90	64	
14	88	65	T
15	86	62	
16	84	65	
17	84	69	
July			
25	95	66	
26	92	71	
27	98	68	
28	101	76	
29	101	74	
30	100	73	T
31	87	72	
August			
1	85	65	
2	86	64	
3	85	73	0.07

*Data before May 6: temperature, 12.5 feet above soil, U.S. Weather Bureau.
**Data after May 6: temperature 6 inches above soil as previously described (2).

Table 6. (continued). Data of temperature, rainfall, evaporation and radiation pertaining to Experiments I-VI, with potassium cyanate on weeds in asparagus, New Brunswick, N.J. 1949.

Interval Date and Hour From	To	Evaporation B* Ml.	Evaporation W* Ml.	Radiation B-W* Ml.	Gram calories/cm²
Experiment I					
4-28 0700	4-29 1000	-	-	-	1487
4-28 0700	5-7 0915	313	147.4	165.6	6239
Experiment II					
5-5 1210	5-6 1145	-	-	-	549
5-5 1210	5-7 0915	-	-	-	999
Experiment III					
5-6 1145	5-6 1300	-	-	-	45
5-6 1145	5-7 0915	42	-	-	450
Experiment IV					
6-14 1030	6-17 1020	170.	115	55	1798
6-17 1020	6-17 1700	30.2	20.8	9.4	392
Experiment V					
7-25 1200	7-25 1620	25.7	18.1	7.6	342
7-25 1200	8-2 1600	485.7	334.7	151.0	5629
8-2 1600	8-3 1645	-	-	-	486
Experiment VI					
8-1 1130	8-2 1600	71.7	47.7	24.0	895.
8-2 1600	8-3 1645	-	-	-	486

*Corrected evaporation from Livingston standardized atmometers.

Weed Control in the Asparagus

Cutting Season with Granular Cyanamid

Experiment VII. On May 27, 1949 granular calcium cyanamid was applied at the rate of 800 pounds per acre to the ridge, 3 feet wide, of asparagus rows of a 6 acre field of Sassafras sandy loam at Deerfield, Cumberland County, N. J. The rate of 800 lbs. cyanamid per acre was previously reported (2) as successful in New Jersey asparagus weed control in 1948. An adjacent 6 acre field was left untreated. The chemical was distributed with a lime spreader early on a dewey morning. A thick growth of crabgrass about 1 inch diameter and a scattered growth of *Polygonum* spp (smartweed), *Chenopodium album*, (lambsquarters) and *Amaranthus retroflexus*, (pigweed), ranging up to about a foot in height was quite effectively killed, as shown in Table 7, ten days after treatment. The weed control took effect shortly after the treatment, however, within 3 or 4 days, and lasted effectively till the end of the cutting season, the last week of June. Table 8, compiled from data taken about one month after treatment, shows that the weed control was still relatively good on treated areas, ranging from about 0-14 weeds per 15 square feet, whereas untreated areas supported a heavy weed population, ranging from 300 to 1000 plants per 15 square feet.

The grading records provided by the P. J. Ritter Co., presented in Tables 9 and 10, show the effect on yield and quality before and after treatment. Inspection of Table 9 will show that the treatment applied on May 27 was followed by a harvest on May 28 of 77% Number 1 grade-no culls-23% butts (3,4) indicating for that day, no adverse quality score due to treatment, as far as damaged or corroded tips are concerned.

Table 10, dealing with quality and grade scores after treatment, shows that on May 31 about 7% more culls were found on treated plots than on untreated areas. No data are available to probe the reason for this. It may be of no significance whatever as far as the treatment with cyanamid is concerned since inspection of the subsequent harvest records shows that occasional variation of 4 or 5 percent culls occurs now on the treated and then on the untreated asparagus.

Weed growth on untreated ridges became heavy enough to justify one cultivation in the relatively dry 1949 season. The approximate date of this cultivation is indicated in Table 10 as June 17. No cultivation was necessary on the treated areas, except between the rows where no cyanamid was spread.

Mr. Leo J. Nocenti, of the P. J. Ritter Co., reports that asparagus seedlings which appeared as volunteers in the asparagus rows were apparently undamaged by the granular calcium cyanamid. This observation suggests the possible value of cyanamid for weed control in seedling asparagus.

It has been shown that under some conditions calcium cyanamid may offer the dual service of weed control and fertilizer (1). The data of Tables 7 to 10 are of interest principally for their data on weed kill or asparagus quality grade. However, a curious difference in yield between treated and untreated fields appears in Table 10 after the rain of 0.33 inch on June 11, namely, the yield from treated fields became consistently about double the yield from untreated fields. On the other hand, before the rain

Table 7. Experiment VII. Weed count in asparagus rows, June 6, 1949, 10 days after application of granular calcium cyanamid, 800 pounds/acre to rows only. Farm of John Johnson, Deerfield, N.J.

Weed number per 15 sq. ft. (Row 6' x 2.5')

west of barn

Random Sample	Treated[1]	Untreated[2]
a	0	624
b	3	720
c	3	636
d	0	960

east of barn

Random Sample	Treated[3]	Untreated[4]
a	0	300
b	3	500

west of barn

[1]Southward, from 3rd row north of barn.

[2]Northward, from 4th row north of barn.

east of barn

[3]Rows 9 to 13 inclusive, south of barn.

[4]Row 8, south of barn and northward. Row 14, south of barn and southward.

Table 8. Experiment VII. Weed count in asparagus rows, June 28, 1949, 32 days after application of granular calcium cyanamid 800 pounds/acre to rows only. Farm of John Johnson, Deerfield, N. J.

Weed number per 15 sq. ft. (Row 6' x 2.5')

West of barn

Random Sample	Treated a	Treated b	Treated c	Untreated[1] a	Untreated[1] b	Untreated[1] c
1	0	6	6	1000	-	-
2	0	0	2	420	750	300
3	1	7	0			
4	0	0	14			

[1] Near stump and untreated areas at end of rows, totally covered with weed growth.

Table 9. Experiment VII. Asparagus yield and quality record[1] before and first day after treatment with granular calcium cyanamide, 800 pounds per acre on rows only, farm of John Johnson, Deerfield, Cumberland County, N. J. 1949.

Date	Weight, Net Pounds/12 acres	Grade, Percent No. 1	Culls	Butts	Precipitation Inches
		Grade Mean			
April 23 through May 20	7240	79 -	2 -	19	3.70
		Grade Range			
		69 -	0 -	31	
		78 -	11 -	11	
		88 -	0 -	12	
May 21	280	84 -	3 -	13	---
22	---	---	---	---	1.04
23	660	72 -	5 -	23	1.36
24	280	80 -	4 -	16	0.57
26	380	78 -	0 -	22	0.07
27	Treatment 800 lbs. $CaCN_2$/acre applied in rows only				Trace
28	200	77 -	0 -	23	0.10
Total	9040				6.84

[1] Data courtesy of Mr. John Johnson and P. J. Ritter Co., Bridgeton, N. J.

Table 10. Experiment VII. Asparagus yield and quality record[1] in relation to treatment with granular calcium cyanamide, 800 pounds per acre on rows only, farm of John Johnson, Deerfield, Cumberland County, N. J. 1949.

Date	Weight, Net Pounds/6 acres		Grade, Percent						Precip-itation Inches
			Untreated			Treated			
	Untreated	Treated	No. 1	Culls	Butts	No. 1	Culls	Butts	
May 30	160	66	82 -	0 -	18	81 -	0 -	19	
31	254	287	77 -	7 -	16	72 -	14 -	14	
June 2	254	231	74 -	0 -	26	74 -	0 -	26	
3	142	259	80 -	0 -	20	76 -	0 -	24	
4	188	183	79 -	0 -	21	80 -	0 -	20	
6	244	503	84 -	0 -	16	76 -	0 -	24	
7	282	173	88 -	0 -	12	80 -	4 -	16	
9	216	313	73 -	0 -	27	79 -	0 -	21	
11	259	236	76 -	0 -	24	80 -	0 -	20	.33
14	104	208	63 -	5 -	32	76 -	0 -	24	
16	244	353	81 -	0 -	19	76 -	0 -	24	.24
17	---	---	probable day of cultivation						.03
18	180	337	70 -	0 -	30	69 -	4 -	27	.25
20	170	320	77 -	0 -	23	78 -	0 -	22	
22	142	297	64 -	4 -	32	76 -	0 -	24	
24	114	228	77 -	0 -	23	80 -	0 -	20	
25	94	132	75 -	0 -	25	80 -	0 -	20	
26	---	---	--	-	--				
27	---	260*	--	-	--	81 -	3 -	16	
28	---	---	--	-	--				
29	---	100*	--	-	--	79 -	0 -	21	
Total	3047	4486							.85

[1] Data courtesy of Mr. John Johnson and P. J. Ritter Co., Bridgeton, N.J.

*A longer cutting season seemed justified on treated areas.

of June 11, yields did not seem consistently related to treatment.

Present inequalities in nutrient units applied to the control and chemically weeded halves of the experiment are as follows:

Material	Lbs. per Acre	Treated N	Treated P_2O_5	Treated K_2O	Untreated N	Untreated P_2O_5	Untreated K_2O	Applied
0-12-12	666	-	80	80	-	--	--	Before cutting
5-10-10	1083	-	--	--	54	108	108	" "
Cyanamid	500	100	--	--	--	--	--	May 27
5-10-10	833	42	83	83	42	83	83	After cutting
TOTAL UNITS		142	163	163	96	191	191	

A soil-testing, amendment program is being undertaken to minimize insofar as possible the differences between the treated and untreated areas.

Summary

Various trials of chemical weeding of asparagus are described:

1. Preliminary experiments with potassium cyanate, 1%, 2% and 2% with wetting agent Vatsol K for chemical weeding of asparagus seedlings.

2. Preliminary experiments with potassium cyanate, 2% with and without Vatsol K for chemical weeding of asparagus during the cutting season.

3. Continuation experiments with potassium cyanate for weed control in asparagus brush.

4. Preliminary experiments on effect of granular calcium cyanamid on yield and quality of asparagus during cutting.

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Effects of Some Herbicides on Strawberry Plants of Various Varieties

F. A. Gilbert[1] and D. E. Wolf[2]

Triethanolamine Salt of 2,4-D

I. Late fall application of 2,4-D to the Sparkle and Pathfinder varieties.

One pound acid equivalent was applied at a volume of five gallons per acre on November 9, 1948 in order to ascertain the effect of a fall application on very small chickweed (Stellaria media) seedlings. The chickweed control obtained was only fair but injury to the actively differentiating fruit buds resulted in a marked yield decrease. Since strawberries differentiate most of their fruit buds during September and October in New Jersey, the major portion of the crop was not seriously injured. The fruit injury observed during the spring of 1949 ranged from slight fasciation to fruit which entirely encircled other berries.

II. Spring and summer applications of 2,4-D to the Sparkle variety.

An experiment was conducted during the 1949 growing season to determine the effect of various times, rates, and number of spray applications to the Sparkle strawberry. The experiment was set up as follows:

Rates:
(1) Check
(2) 1/2 lb./acre
(3) 1 lb./acre

Number of Sprays and Dates of Application:
(1) 1 spray (June)
(2) 2 sprays (June, July)

Replications: 4

In order to readily make comparisons of the various treatments, the plots were examined and given a numerical rating from 1 to 5 on September 1, 1949. A rating of 1 was given to plants which appeared normal, and progressively higher numbers up to 5 were assigned for various growth characters as apparent injury increased.

Table I summarizes these data.

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[1]Research Associate, New Jersey Agricultural Experiment Station.

[2]Agent, United States Department of Agriculture and Associate Research Specialist, New Jersey Agricultural Experiment Station.

Table I

Resistance of Sparkle Strawberry Plants
To Triethanolamine Salt of 2,4-D

Treatment	Numerical Value*
Check	1.4
1/2 lb./acre (1 application)	2.3
1 lb./acre (1 application)	2.4
1/2 lb./acre (2 applications)	3.1
1 lb./acre (2 applications)	3.6

* Numerical values designated on the following basis:
1 equals normal plants and matted rows.
5 equals very poor plants and rows.

III. The effect of 2,4-D on ten commercial varieties of strawberries grown in New Jersey.

In order to ascertain the degree of resistance to 2,4-D of some important varieties of strawberries grown in New Jersey, the following experiment was conducted in 1949:

Varieties: Sparkle, Pathfinder, Julymorn, Redwing, Midland, Blakemore, Fairland, Fairfax Dorsett, Redcrop.

Rate: 1 lb. acid equivalent/acre

Number of Sprays: 1

Dates of Application: July

Replications: 4

The plots were given a numerical rating as described under II and the data are summarized in Table II.

Table II

Relative Resistance of 10 Strawberry Varieties
To The Triethanolamine Salt of 2,4-D

Variety	Numerical Value
Dorsett	1.5
Redwing	1.6
Fairfax	1.7
Redcrop	1.8
Blakemore	1.8
Fairland	2.2
Pathfinder	2.7

Table II (continued)

Variety	Numerical Value
Sparkle	2.9
Midland	3.1
Julymorn	3.5

Note: All data herein reported regarding the effect of the Triethanolamine salt of 2,4-D sprays on strawberry plants is for 1949 when it was extremely dry during June and July.

Conclusions

1. Triethanolamine salt of 2,4-D should not be applied during the fall when fruit buds are actively differentiating.

2. Severe injury to strawberries may result from 2,4-D applications during extended drought periods.

3. Some varieties of strawberries show a more marked resistance to 2,4-D than do others.

Sodium 2,4 Dichlorophenoxy Ethyl Sulfate (E.H. #1)

I. Summer application

Experimental Herbicide #1 (Carbide and Carbon Chemical Corporation), which is a seed toxicant, was sprayed on eleven varieties of strawberries on August 17, 1949. This spray application was made immediately following a thorough hoeing. Two concentrations, three and six pounds of E.H. #1 per 100 gallons of water, were sprayed on the plants at the rate of 100 gallons per acre. Both concentrations gave excellent control of weeds, particularly chickweed (Stellaria media) for six weeks with no apparent deformation or retardation of the strawberry plants. Eight weeks after the sprays were applied, chickweed seedlings began to push through in the sprayed plots. However, at the end of this same eight week period, the check plots were completely overgrown with chickweed.

II. Late spring application

On June 23, 1949, three and six pounds of E.H. #1 per 100 gallons of water were applied to small plots of the Sparkle strawberry variety. Both concentrations gave excellent weed control for a period of six weeks when applied immediately following complete tillage.

Conclusions

Experimental Herbicide #1 gives evidence of being a very desirable weed control material for strawberries since the two exploratory experiments gave excellent results--no noticeable injury to the strawberry plants--excellent control of weeds, particularly chickweed (Stellaria media).

Protection of Strawberry Plants with Activated Carbon in Pre-Planting Applications with 2,4-D

by
R. F. Carlson, J. E. Moulton and C. L. Hamner[1]

The use of 2,4-D as a post- and pre-planting herbicide for control of many weeds in new strawberry plantings has shown considerable promise (2 and 3). However, in pre-planting applications with 2,4-D, the roots are exposed to the chemical and often show slight injury from applications higher than two pounds per acre. It has been shown that 2,4-D is absorbed on charcoal (4). Further, activated carbon has been used to inactivate 2,4-D on sweet potato slips at herbicidal applications (1). The purpose of the tests reported in this paper was to determine the possibility of protecting strawberry plants from 2,4-D where large dosages are needed for satisfactory control.

Materials and Methods

The soil, a Hillsdale sandy loam, was treated with 2,4-D one month before planting and then again immediately before the plants were set. In each case rates of 2 and 3 pounds per acre of actual 2,4-D (2,4-Dow, Formula 40) were used, making a total of 4 and 6 pounds per acre respectively. In each case enough of the solution was sprayed to moisten the surface of the soil. The premier variety was used for the tests.

A planting was made on May 18 and within 24 hours a one-inch rain occurred. A second planting was made 24 hours after this rain, thus giving a comparison of the effect of rainfall upon the treatments. Prior to planting, some plants were dipped in dust of activated carbon (nu char C) and other plants were set without first treating them.

The plots that were treated and planted before the rain produced nearly normal stand of plants whether dipped in carbon or set without carbon treatment. Most likely the rain that immediately followed planting washed the major portion of 2,4-D from the root zone. However, there were slight formative, but not injurious effects of 2,4-D on plants that were set without first treating them with carbon, whereas the carbon treated plants showed no such effects. This was most noticable at the high rate of 6 pounds per acre.

The plots that were treated and planted following the rain showed striking differences between carbon-treated and untreated plants. After two weeks most of the plants that were unprotected with carbon were dead at the high concentration (6 lbs./A) of 2,4-D, whereas the carbon-treated plants were growing satisfactorily. At the low rate per acre, this difference was not as great. (Table 1).

Except for smartweed (Polygonum persicaria L.) and a few grasses, the weeds were controlled satisfactorily at both rates of 2,4-D used.

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1 Horticulture Department, Michigan State College, East Lansing, Michigan

Table 1. Percent of plants that survived with and without carbon treatment after being planted before and after rain on soil treated with 2,4-D at two rates per acre.

Treated and Planted before Rain			Treated and Planted after Rain		
Row	Carbon Treated	No Carbon	Row	Carbon Treated	No Carbon
		Total 2,4-D: 6 lbs./A.			
	Percent	Percent		Percent	Percent
1	88.8	61.1	7	83.3	5.5
2	94.4	72.2	8	88.8	16.6
3	88.8	77.7	9	88.8	16.6
4	94.4	83.3	10	94.4	11.0
5	94.4	88.8	11	94.4	22.1
6	94.4	83.3	12	88.8	11.0
		Total 2,4-D: 4 lbs. /A.			
13	94.4	94.4	19	100.0	77.7
14	100.0	88.8	20	94.4	83.3
15	88.8	94.4	21	100.0	50.0
16	100.0	100.0	22	100.0	88.8
17	100.0	83.3	23	94.4	83.3
18	94.4	88.8	24	100.0	77.7

Discussion

From this preliminary work using activated carbon in transplanting strawberry plants in conjunction with weed control, it was found that plants were protected from 2,4-D injury. The plants set, after the rain, in the 2,4-D treated soil received the most benefit from the carbon. The soil being of the mineral type and a dry period following the planting caused the 2,4-D to remain in the root zone for several weeks. The carbon surrounding the plant evidently inactivated enough 2,4-D so that the toxic effect was greatly reduced to provide normal growth for the plants during this period.

On lighter mineral soil where 2,4-D **persist** longer than on organic soil, activated carbon will give added protection to the strawberry plants where 2,4-D is used commercially as a pre-planting application for the control of many of the noxious weeds.

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Effect on Sweet Corn Productivity of 4 Compounds of 2,4-D Sprayed Post Emergence Above or Below the Corn Foliage

C.H. Dearborn[1]

Our knowledge of weed control in sweet corn with 2,4-D has progressed rapidly since the preliminary report of Shafer, et al (2) in 1946. It is generally agreed that sweet corn can be weeded with 2,4-D. However workers are not in agreement on which forms of 2,4-D to use or when and how to apply them. The studies at Geneva have been primarily concerned with the use of 2,4-D not at planting time but rather at emergence of the corn or stages in its growth thereafter. From this approach 2,4-D will be neither condemned for poor germination of the corn nor wasted in case the stand of corn is too poor to retain for a crop. Furthermore the cost of materials per acre is at least 50 per cent less than the cost of that which is being used immediately following planting. Post emergence treatments at 3/4 of a pound of 2,4-D acid equivalent per acre have not been as effective in controlling annual grasses as have the higher rates sprayed pre-emergence to corn. 2,4-D was recommended for use on sweet corn in 1949 based on the results of the 1947 and 1948 studies. The conditions set forth were that 3/4 of a pound per acre acid equivalent of the amine salt should be sprayed over the corn and weeds at emergence or up until the corn was 8 inches tall. One half pound of the amine salt of 2,4-D per acre was recommended as a complete cover spray for sweet corn up until the crop was nearly showing the tassel. Sprays applied at these later stages of corn development have resulted in intense green color of the corn foliage, failure of the tassel to break thru the tightly rolled leaves of the crown and delayed ripening of the grain. Different formulations of 2,4-D often appear to affect the sweet corn differently when used at the same rate per acre or when applied in conjunction with cultivation. The purpose of this study was to determine if the yield of sweet corn would be affected when the crop was sprayed at a late stage of growth with four formulations of 2,4-D in conjunction with cultivation.

Materials and Methods

The experimental site was 112' X 500' located on fertile Ontario silt loam soil in a 6 acre field of Golden Cross Bantam sweet corn. On June 6 the corn was planted with a 4 row planter 28 inches between rows. The corn was cultivated June 20 and July 11 only. In conjunction with the last cultivation, at which time the corn was 2 feet tall, 4 formulations of 2,4-D were applied separately on plots 4 rows wide and 100 feet long. All sprays were applied from a tractor equipped to spray and cultivate two rows at a time. A boom was mounted in front and one on the rear of the tractor in order that sprays might fall on the soil and be cultivated in or fall on the soil and remain undisturbed for the remainder of the season. There were 3 drop pipes and 4 fan nozzles per boom. Both were attached to the tractor so that the drop pipes could be rotated up and down to permit spraying above the crop or below the corn foliage. All sprays contained the equivalent of 3/4 of a pound of 2,4-D acid in 13.7 gallons of water. They were applied at this rate per acre and at 35 pounds pressure. The

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[1]Assistant Professor Vegetable Crops. Contribution from Division of Vegetable Crops. Journal Paper No. 809 of the New York State Agricultural Experiment Station published with the approval of the Director.

chemicals used were: two formulations[2] of the triethanolamine salt, isopropyl ester and ethyl ester of 2,4-D. The test for a given chemical involved cultivation, the application of a spray in front of the tractor above the corn, in front and below the corn foliage, in the rear above the corn and in the rear below the corn. Chemicals, positions of sprays, check plots and replicates were well randomized. There were 60 plots embracing 3 replicates of 4 chemicals applied in 4 positions plus the cultivated unsprayed check.

Notes on the response of the corn and weeds were recorded. Yield of unhusked corn and number of ears per plot were recorded at the prime canning stage of the sweet corn from two 50 foot sections of the two center rows in each plot. It seems well to point out that 0.36 of an inch of rain fell one week after spraying, 1.20 inches two weeks after spraying and 0.30 inches on July 31 or 20 days after the sprays were applied. In August there were two showers totaling 0.73 inches of rainfall. Considering the fact that the months of May and June were very dry, it is evident that the soil moisture was below normal for this area.

Results

The data in Table 1 show that neither the chemical used in weeding nor the position from which it was sprayed produced any significant difference in the yield of sweet corn.

Table 1. Effect on yield in tons of sweet corn of 4 formulations of 2,4-D applied from tractor mounted spray booms.

	SPRAY NOZZLES					
	FRONT		REAR			
	Above*	Below	Above	Below	Tons Ave.	Check
Amine Salt	2.8**	2.9	2.3	3.0	2.7	2.7
Amine Salt	2.9	3.1	2.9	2.9	2.9	2.7
Isopropyl Ester	2.9	2.7	2.7	2.9	2.8	2.4
Ethyl Ester	3.0	2.4	2.8	2.8	2.5	2.6
Average	2.9	2.8	2.7	2.9		2.6

Differences not statistically significant at 5% level.
* Above corn and weed foliage.
** Each figure is average of 3 replicates.

This is in agreement with the 1947 results (1) in that 0.6 and 0.8 of a pound of 2,4-D sprayed over sweet corn at a late stage of growth did not affect the yield of corn. Thus with regard to Golden Cross Bantam sweet corn it seems safe and practical to use a complete cover spray of 3/4 pound of 2,4-D on weedy corn that has developed to an average height of 2 feet. Since the yield of corn was not affected by the treatments any differences in weed control due to the method of application becomes highly significant. In this respect it was noted

[2] The formulations were Chipman Amine equiv. to 40% acid, Dow formula 40 equiv. to 40% acid, esteron 44 equiv. to 37% acid and Weedone conc. 48 equiv. to 31.2% acid. The writer gratefully acknowledges the materials furnished by Dow Chemical Co., Midland Mich. and by American Chemical Paint Co., Ambler, Penna.

that the sprays applied above the corn either in front or in the rear of the tractor gave a complete kill of those weeds sensitive to 2,4-D even though they stood as high as the corn. In contrast, where the sprays were applied below the corn or 8 to 12 inches above the ground only the lateral branches of Lambs quarters (Chenopodium album) Red root (Amaranthus sp) and Ragweed (Ambrosia) were killed. The ester killed a higher proportion of the lateral branches but did not as a rule kill the terminal growing point when applied below this region of the plant. Rolling of the corn leaves occurred only where the esters were used, however, the response was not extensive or serious.

As might be expected the 3/4 pound of 2,4-D sprayed forward of the tractor and mixed into the soil with the cultivator failed to prevent the germination and growth of weed seeds that were turned up by the cultivator. At this late stage of corn development these weeds were not important yet the test demonstrated that a more lasting job of weeding was obtained from the 2,4-D used following cultivation.

Summary

In view of the uniform yield of sweet corn produced by the various treatments irrespective of chemical used or method of application several facts are extremely important to the sweet corn grower.

First; the weeding of sweet corn can be satisfactorily accomplished with the equivalent of 3/4 of a pound of 2,4-D acid per acre applied when the corn is breaking ground or until the crop is 8 inches tall. Second; if it is impossible to spray the corn during this period the same rate of 2,4-D per acre may be used with equal success in killing the weeds providing the spray nozzles are carried high enough to cover the terminal growth of the sensitive weeds. Third; more visible crop response in the form of leaf rolling may be expected with the later applications particularly if the ester forms of 2,4-D are used. Fourth; sprays of 2,4-D applied in conjunction with cultivation but following the stirring of the soil inhibited weed growth longer than the same concentration applied and mixed with the soil directly by the cultivator teeth. No evidence was gathered during this very dry season to indicate that the growth of corn was modified more by 2,4-D where it had been applied to the soil and left undisturbed for the remainder of the season than where it was cultivated in directly after spraying.

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Low-Gallonage Directional-Spray Equipment for Applying Herbicides in Row Crops

C. W. Terry[1], R. D. Sweet[2],
S. L. Dallyn[3], and G. M. Taylor[4]

The equipment for applying herbicides to weeds in row crops was attached to a Farmall AV tractor.

For the experiments only a small quantity of the spray liquid was required so a gallon can served as a reservoir.

The 3/8" Bronze gear pump was belt driven from the tractor pulley. It was mounted on a channel which was bolted to the tractor frame.

An adjustable built-in relief valve allowed control of the pressure to the nozzles.

The pressure gage and shutoff valve were located in convenient positions for the tractor operator.

One-fourth inch galvanized steel pipe and fittings were used for all rigid piping and neoprene hose of a size that would fit tightly over the pipe was used for all flexible connections.

Screens or filters were not used but the operators were careful to prevent dirt from getting into the system.

The shoes which carried the nozzles were made from a design by O. B. Wooten, Jr., Delta Branch Experiment Station, Stoneville, Mississippi. Slides will show the construction. These shoes were mounted on bars which are normally used to carry cultivator teeth on the tractor. The height could be adjusted at will through hydraulic "Touch Control" mechanism.

Guards to pick up the plants and prevent their being sprayed were fashioned out of sheet metal and fastened to the shoes. The whole nozzle, support, and guard "floated" over the ground close to the plant row and allowed application of the spray material to the weeds while getting only a very small amount on the plant stems and a few leaves.

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[1]Professor, Department of Agricultural Engineering, Cornell University, Ithaca, New York

[2]Associate Professor, Department of Vegetable Crops, Cornell University, Ithaca, New York

[3]Graduate Assistant, Department of Vegetable Crops, Cornell University, Ithaca, New York

[4]Student Assistant, Department of Agricultural Engineering, Cornell University, Ithaca, New York

Nozzle size was selected to give the proper quantity (gal. per acre) on the strip when using a pressure that gave the proper atomization and distribution of the spray material.

The shape of guard used is governed by the kind and size of plants. Particular care must be exercised when plant stems extend across between the rows since they may catch and be broken. For early treatments, this was not a serious problem.

Before using the outfit, nozzles were calibrated to determine discharge at various pressures. Tractor speed was checked in each gear for each of several throttle governor settings, so it was possible to control the applications quite accurately.

In order to more accurately observe distribution of the spray the gallonage used was quite high. For most of the work the pump was adjusted for 10-15 lbs. pressure and about 45 gallons per acre of the spray applied. This rate was calculated on the basis of the area actually covered--approximately an 8 inch strip down each row. With this amount of solution there was some runoff from the stems and the material tended to collect around the base just below the ground surface. Such a situation is undesirable, as injury is increased at this point. It is believed that the rate can be markedly reduced without reducing the effectiveness of the spray provided a higher pressure is used to give finer atomization of the material.

Since the principle of the machine is to apply the spray material close to the ground, it is obvious that the weeds must be small at the time of treatment otherwise they escape serious injury in the same manner as do the crop plants. An exception to this is found in the case of grasses sprayed with oil. Even when the grass is 6-8 inches tall an application of oil on the lower part of the stems seems to penetrate and seriously affect them. Creeping weeds such as portulaca (purslane), and knotweed are particularly vulnerable since practically their whole surface can be covered even on plants several weeks old.

A Progress Report on Chemical Weed Control in Asparagus, Lima Beans, Cantaloupes, Potatoes, and Sweet Corn[1]

E. M. Rahn and W. L. Ogle[2]

This is a brief account of the work done during 1949 on chemical weed control in asparagus, lima beans, cantaloupes, potatoes, and sweet corn. An attempt was made in most cases to substitute chemical weed control for hand hoeing and a portion of the regular tractor cultivation. Experiments with asparagus, lima beans, and cantaloupes were located on Norfolk loamy sand while those with potatoes and sweet corn were on heavier Sassafras silt loam soils. All chemicals, except granular cyanamid, were applied as water solutions or suspensions at a rate of 75 gallons per acre. Monarch No. 59 nozzles were used which gave a fan-type spray. The 2,4-D used was of the alkanolamine form (Weedar 64).

Asparagus

Treatments were made both at the beginning and end of the harvest season after discing. Plots receiving chemical treatment were not cultivated except where granular cyanamid was used. Here an 18-inch band over the row was treated and the remaining area was cultivated. Plots were five feet (1 row) by 50 feet, replicated five times. Best control (Table 1) during the harvest season was obtained with sodium pentachlorophenate (Dowicide G) and granular cyanamid. The former was applied April 7, ten days after discing, but before crop emergence. The latter was applied when weeds were about two inches tall on May 6. Yields were not significantly affected by any treatment.

Best control during the post-harvest season was with aerocyanate and granular cyanamid. The former was applied as a two per cent spray plus spreader whenever weeds were breaking through. Three applications were made. The spray was directed to the base of the asparagus shoots, injuring the lowest branches only and apparently not the main stems. Cyanamid applied as above gave good control, too, but was difficult to apply. Crabgrass was the most prevalent weed in the post-harvest season.

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[2]Assistant Research Professor and Research Assistant, respectively, at the Delaware Agricultural Experiment Station.

Table 1. Results of Asparagus Chemical Weed Control, 1949

Chemicals and Rates per Acre	Weight of Weeds per 3 Sq. Ft., Gms. 5/27/49 (During Harvest)	8/15/49 (After Harvest)	Yield, lbs., 5 replications
2,4-D, 2 lbs., pre-emergence	24	320	39
2,4-D, ½ lb. (2 applic.), post-emergence	23	350	39
Na pentachlorophenate, 20 lbs., pre-emergence	2	370	39
Granular cyanamid, 200 lbs., post-emergence	3	20	39
Aerocyanate, 2% spray (3 applic.), post-emergence	160	10	38
Check, never cultivated	517	385	42
Check, full cultivation	-	-	40
L.S.D. at 5% point	-	-	N.S.

Lima Beans

Two experiments were conducted. Following seeding of the first experiment on May 27, there was an extended dry period of six weeks. On the other hand, following seeding of the second experiment on July 19, there was a moderate amount of rainfall. Three-row plots, 1/250 acre in size, were replicated four times. One treatment received full cultivation and hoeing. All other treatments including the untreated check and those receiving chemicals were not cultivated until plants were about six inches high, after which they received regular cultivation. These plots were never hoed.

The outstanding treatments and their results are presented in Tables 2 and 3. Use of 2,4-D gave only fair weed control in the first experiment but good control in the second when moisture following application was more plentiful. A dinitro, Koppers Selective K-1131, applied right after seeding gave excellent weed control in both experiments. Another dinitro, Dow Selective Weed Killer applied similarly, as well as Dowicide G (Na pentachlorophenate) gave perfect weed control in the second experiment.

Although 2,4-D gave only fair weed control in the first experiment, yields and stand where the 1½-pound rate was used were good. Yields were highest, however, on the full-cultivation check plots. The second experiment was seeded too late and as a result frost came when pods were about half grown. Consequently, yield data were unattainable but the weights of plants in the center rows of the plots on October 13, two weeks before frost, are presented as an indication of the toxicity of the chemicals. In this experiment, with regard to weed control, stand, and weight of plants, sodium pentachlorophenate, Dow Selective, and Koppers Selective K-1131 Weed Killer looked particularly good. They were applied immediately after seeding. The rate of application of these chemicals could be reduced to one third of that indicated if only a 12-inch band over the row was treated. The use of 2,4-D in the second experiment, in contrast to the first experiment, resulted in good weed control, but in considerable reduction in stand.

Table 2. Outstanding Treatments of First Lima Bean Weed Control Experiment. Seeded May 27, 1949.

Chemicals and Rates per Acre	Wt. of Weeds 3 Sq. Ft., Gms., 7/21/49	Stand	Yield of Shelled Beans per Acre, lbs.
2,4-D, 1 lb., 5 days after seeding	73	Good	1107
2,4-D, 1½ lbs., 5 days after seeding	49	"	1416
2,4,5-T, 1 lb., 5 days after seeding	32	"	1216
E.H. No. 1, 3 lbs., 5 days after seeding	48	"	1198
Koppers Selective K-1131, 5 gals., at seeding	8	"	1162
Check, first cultivation omitted	195	"	962
Check, full cultivation	0	"	1634
L.S.D. at 5% point	-	-	458

Table 3. Outstanding Treatments of Second Lima Bean Weed Control Experiment. Seeded July 19, 1949.

Chemicals and Rates per Acre	Wt. Weeds per 3 Sq.Ft., Gms. 9/16/49	Stand, % of Check	Wt. Plants, 4 Replications, lbs., 10/13/49*
2,4-D, 1 lb., at seeding	30	71	53.1
2,4-D, 1 lb., 3 days after seeding	30	71	47.0
2,4-D, 1½ lbs., 3 days after seeding	20	63	43.2
2,4-D, 2 lbs., 3 " " "	0	25	37.9
2,4,5-T, 1½ lbs., 3 " " "	17	67	50.0
E.H.No. 1, 3 lbs., 3 " " "	0	46	47.5
Na Pentachlorophenate, 30 lbs., at seeding	0	92	57.4
Dow Selective, 7½ gals., at seeding	0	100	65.4
Koppers Selective K-1131, 7½ gals., at seeding	0	67	57.0
Check, first cultivation omitted	299	100	44.0
Check, full cultivation	0	92	43.5
L.S.D. at 5% point	-	-	14.4

* Frost killed the plants before pods were fully developed. Therefore, weight of plants in the center row of each plot was taken previous to frost as an indication of the toxicity of the chemicals used.

Cantaloupes

A number of treatments were tried with cantaloupes but the only ones that were of value are listed in Table 4. Two-row plots, 1/150 acre in size, were replicated four times. As with lima beans, only one treatment received full cultivation and hoeing. The first cultivation was omitted on all other treatments. Plots receiving the chemicals listed in Table 4 received a very light hoeing on June 21, after records on weed growth were obtained, and when the cantaloupe plants were starting to "vine-out". Much less hand-hoeing was necessary on these plots than on the check plots, and it was felt that the use of chemicals was quite worthwhile for that reason. The rate of application could be reduced to about one-fifth of that indicated if only a 12- to 18-inch band over the row were treated. The Na pentachlorophenate was applied right after seeding and was not quite so effective as contact pre-emergence applications of Dow Selective Weed Killer and Shell Weed Killer 130.

Table 4. Outstanding Treatments of Cantaloupe Weed Control Experiment, 1949.

Chemicals and Rates per Acre	Wt. of Weeds per 3 Sq.Ft., Gms., 6/16/49	Stand, % of Check	Yield, Mkt. Melons per Acre
Na pentachlorophenate, 20 lbs., at seeding	68	95	6450
Dow Selective, 1 gal., 5 days after seeding and 14 days after soil preparation	8	100	8325
Shell Weed Killer 130, 5 gals., 5 days after seeding and 14 days after soil preparation	2	100	8513
Check, first cultivation omitted	377	100	413
Check, full cultivation	0	100	6525
L.S.D. at 5% point	-	-	1625

Potatoes

Three-row plots, 1/200 acre in size, were replicated four times. Yield records were taken from the center row only. Potatoes of the Katahdin variety were planted March 30, and the chemicals listed in Table 5 were applied fifteen days later. Plants did not come up for a week or more after this date. Only one treatment received full cultivation and hoeing. All other plots were not cultivated until early bloom stage. They received two instead of the usual four cultivations and were never hoed.

Yields were significantly better where full cultivation was given. All chemicals used gave good control. Apparently, however, the potato plants in this experiment needed full cultivation even though weeds were not a problem.

Table 5. Results of Potato Weed Control Experiment, 1949

Chemicals and Rates per Acre	Wt. of Weeds per 3 Sq.Ft., Gms., 6/7/49	Yields, Bu. per Acre
2,4-D, 1½ lbs., pre-emergence	19	263
2,4,5-T, 1½ lbs., "	16	231
Na pentachlorophenate, 20 lbs., pre-emergence	8	272
TCA, 30 lbs., pre-emergence	5	227
Dow Selective, 5 gals., pre-emergence	13	273
Check, first 2 cultivations omitted	403	189
Check, full cultivation	4	331
L.S.D. at 5% point	-	57

Sweet Corn

Four-row plots, 1/100 acre in size, were replicated four times. Records were taken from only the center two rows. Seed of the Tendermost variety was planted on June 3. Treatments and results are presented in Table 6. Plots treated with chemicals were not cultivated until the corn was about a foot tall, the first two cultivations being omitted. Four cultivations and one hoeing were given the check plots receiving full cultivation. Post-emergence applications were made on June 21, a hot day, when the corn was about six inches tall and the weeds were about two inches tall.

Results in Table 6 indicate that 2,4-D was very effective for weed control. A pre-emergence application of as little as one-half pound per acre gave fair control. A post-emergence application of as little as one-fourth pound likewise gave satisfactory control. The results also indicate that yields were not sacrificed by eliminating the first two cultivations, nor by eliminating all cultivation so long as the weeds were controlled by shallow scraping.

Table 6. Results of Sweet Corn Weed Control Experiment, 1949

Chemicals and Rates per Acre	Wt. of Weeds per 3 Sq.Ft., Gms., 7/22/49	Stand, % of Check	Yield, Tons per Acre
2,4-D, ½ lb., at seeding	140	100	3.0
2,4-D, 1 lb., at seeding	60	100	3.1
2,4-D, 1½ lb., at seeding	35	100	3.1
2,4-D, 1 lb., 5 days after seeding	10	92	2.7
2,4-D, ¼ lb., post-emergence	15	100	3.3
2,4-D, ½ lb., post-emergence	12	100	3.8
2,4,5-T, 1 lb., at seeding	60	100	2.2
Na pentachlorophenate, 20 lbs., at seeding	20	100	3.3
Check, never cultivated	1816	100	0.5
Check, full cultivation	0	100	3.3
Check, scraped only	0	100	3.6
Check, scraped with last 2 cultivations	0	100	3.4
L.S.D. 5% point	-	-	0.9

Chemical Weed Control in Sweet Corn, Spinach, Asparagus, and other Vegetable Crops

Charles J. Noll and Martin L. Odland [1]

Weed control experiments using chemical herbicides were carried on this year on sweet corn, spinach, asparagus, and peas. The chemical herbicides used included 2,4-D and related compounds, dinitros, petroleum products, cyanamid, and miscellaneous materials. All sprays were applied with a knapsac sprayer at the rate of 50 to 100 gallons per acre. The soil type was Hagerstown silt loam. Rainfall was less than normal.

Sweet Corn Weed Control

The variety Ioana was used in this test. This variety had been reported as somewhat resistant to 2,4-D injury. The alkanalamine salt of 2,4-D was the herbicide used. The plots comprised of a single row 100 feet long were replicated six times. The chemical was sprayed over the row for a width of ten inches both as a pre-emergence and a post-emergence application. Pre-emergence rates of treatments were 0, 2, 4, 6, and 8 pounds acid equivalent per acre and post-emergence rates of treatments were 0, 1, 2, 3, and 4 pounds acid equivalent per acre. The two treatments were combined in all possible combinations totaling 25 treatments.

The corn was machine planted on June 9th and the pre-emergence treatment was applied the following day. The post-emergence treatment was applied when the corn was 3 inches tall.

Weeds were not a serious problem either in the sprayed or unsprayed rows. Two cultivations controlled the weeds between the rows. Only the heavier applications of 2,4-D applied as a post-emergence spray produced visible injury to the young corn plants. Later in the growing season practically no visible difference could be found between the sprayed and the unsprayed rows of corn.

Ear number and ear weight data were obtained and are graphically presented in figures 1 and 2. The reduction in number of ears per each increasing unit of 2,4-D applied as a pre-emergence treatment is above 21 ears or four per cent. Thus the heavier applications reduced the number of ears significantly. Similiar results were obtained from post-emergence applications at rates twice as great as those applied as a pre-emergence treatment.

The reduction in yield (fig. 2) for each unit of 2,4-D applied as a pre-emergence spray is about 12 pounds or four and one-half per cent. Similar results were obtained from the units

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[1] Assistant Professor and Professor of Olericulture respectfully, Department of Horticulture, School of Agriculture and Experiment Station, The Pennsylvania State College, State College, Pa.

of 2,4-D applied as post-emergence treatment. The differences required for significance at the 5 per cent level is 9.7 pounds for the pre-emergence and 15.2 for the post-emergence. As may be noted in the fig. 2 the reduction in yield as a result of the 2,4-D treatment is significant. If weeds had been a greater problem, reduction in yield caused by the treatments would, no doubt, have been of less importance.

Spinach Weed Control

The variety Bloomsdale Long Standing was used in this test. Single row plots 23 feet long, replicated four times, were sprayed over the row for a width of 18 inches. All applications were pre-emergence.

The land was prepared on April 29, planted May 11, and the herbicides applied May 16. No rains fell between April 28 and May 14. Harvest was made on June 25.

The treatments and the results are presented in Table I. All of the treatments reduced the stand of weeds. Yields were significantly increased over the check by only one chemical, Dowicide G, at the rate of 2½ lbs. per acre. The first 10 materials listed significantly decreased the yield over the check. Stand of plants was also significantly reduced as compared to the check by the first 10 treatments and by Shell Oil 130 at the heavier application.

A fall crop of spinach was successfully grown, free of weeds without cultivation by doubling the seeding rate and by using Shell Oil 130 at 10 gallons per acre with or without a delay in planting after the soil was prepared. Stoddard Solvent was successfully used under a delayed planting system.

Asparagus Weed Control

Single row plots 5' x 87' (1/100 acre), replicated four times, were treated with 9 herbicides at a number of different rates of application. These plots have received approximately the same treatment for three seasons.

The land was disced April 15, cultivated April 18, sprayed with 2,4-D and related compounds April 21 and 22, and with the other herbicides April 27. The second application of all the chemicals except cyanamid was made May 25. Estimate of weed growth was made May 24.

The material, rate of application, yield and weed control are presented in Table II. The weed populations in the different plots were not alike. In the plots where 2,4-D had been applied the weeds were generally grasses. In other plots chickweed and smart weed were the dominate weeds. The best weed control was with 2,4-D in the form of the butyl ester at 4 lbs. per acre and with Dow Selective, Stoddard Solvent, and Granular Cyanamid at the rate of

800 lbs. per acre. Some treatments significantly reduced the yield as compared to the check.

Pea Weed Control

The variety Thomas Laxton was used in this test. Plots 5' x 58', replicated four times, were sprayed with chemical herbicides.

The land was prepared on April 29 and seeded with a grain drill the same day. The pre-emergence sprays were applied May 5 and the post-emergence sprays were applied on June 1 when the peas were 6" tall. Harvest was made from the 20th to the 24th of June and weight of peas in the pod and total weight of the weeds recorded.

The treatments and the results are presented in Table III. There was no significant difference between yields. All treatments significantly reduced the growth of weeds. The best weed control was with Dow Selective at the rate of 3 qts. in 100 gallons of watter at 100 gallons per acre.

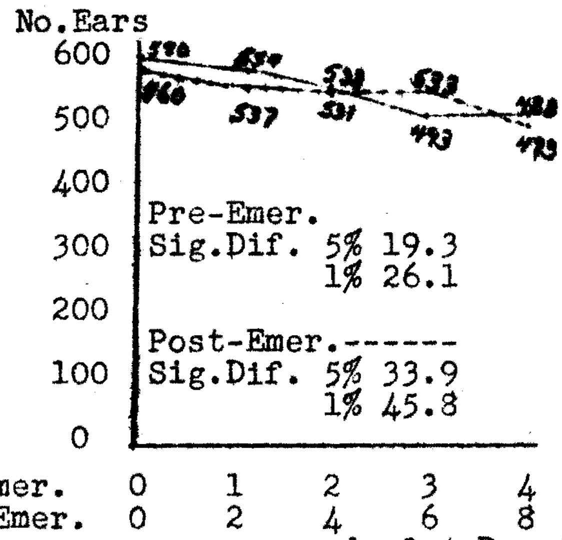
Other Weed Control Sprays

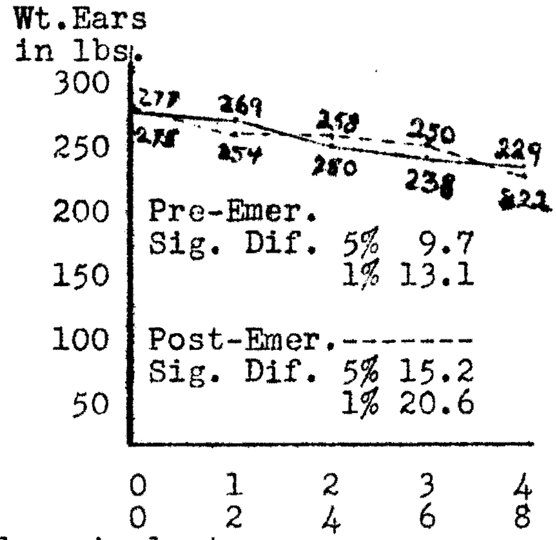
Preliminary work on chemical weed control in lima beans using eleven chemicals at varying strengths were included in a pre-emergence trial. All chemicals at all rates gave a larger yield than the untreated, unweeded plots. The treatments include three forms of 2,4-D, ACP 549, Exp. Herbicide No. 1, Dow Selective, Sinox, Dowicide G, Shell Oil 130, Esso Weedkiller 45, and XP-40A. One of the most promising materials used was Dowicide G. At a rate of 7½ lbs. per acre weed control was good and there was no visible injury to the lima bean plants.

All hand weeding was eliminated in carrots by spraying the rows with Stoddard Solvent at the rate of 90 gallons per acre. One or two applications were made.

Onions in a variety test were weeded with potassium cynate. Weeds were not eliminated by the herbicides but the weed population was greatly reduced with little injury to the onions by using a 1% and later a 2% spray.

The following companies furnished the herbicides used in these experiments: American Chemical Paint Company, American Cyanamid Company, Associated Chemists, Incorporated, Carbide and Carbon Chemicals Corporation, Dow Chemical Company, Esso Standard Oil Company, Shell Chemical Corporation, Sherwin-Williams Company, and Standard Agricultural Chemical, Incorporated.





Pre-Emer. 0 1 2 3 4 0 1 2 3 4
Post-Emer. 0 2 4 6 8 0 2 4 6 8
pounds 2,4-D acid equivalent per acre

Fig.1. Effect of Treatment on Total Number of Ears.

Fig.2. Effect of Treatment on Total Weight of Ears.

Table I. Effect of Chemical Herbicides on Stand and Weight of Spinach and on Weed Growth.

	Material	Rate of Application per acre	Number of Plants	Yield in lbs.	Weed Control (1-10)+
1	2,4-D Amine	1 lb.	2.5	.03	2.5
2	2,4-D Amine	2 lbs.	1.9	.00	2.3
3	2,4,5-T	1 lb.	14.0	.18	3.8
4	2,4,5-T	2 lbs.	3.3	.08	2.3
5	ACP 549	1/3 gal.	25.0	.35	5.8
6	ACP 549	2/3 gal.	9.0	.13	5.5
7	ACP 646	1 lb.	26.3	.30	7.8
8	ACP 646	2 lbs.	25.0	.35	8.0
9	Exp. Herb. No. 1	2½ lbs.	2.5	.03	9.3
10	Exp. Herb. No. 1	5 lbs.	3.3	.05	9.0
11	Dow Selective	1 gal.	102.3	1.85	8.3
12	Dow Selective	2 gals.	109.0	2.15	6.5
13	Dowicide G	2½ lbs.	86.5	2.70	8.5
14	Dowicide G	5 lbs.	89.5	1.50	7.5
15	Sinox	1 gal.	78.0	.95	8.3
16	Sinox	2 gals.	73.3	1.10	8.0
17	Shell Oil 130	5 gals.	85.8	2.15	4.0
18	Shell Oil 130	10 gals.	50.0	1.18	2.0
19	Esso Weedkiller 45	45 gals.	67.0	1.53	5.8
20	Esso Weedkiller 45	80 gals.	87.8	1.43	5.8
21	Stoddard Solvent	80 gals.	92.8	1.75	5.5
22	Nothing-Uncultivated		82.3	1.23	10.0
	Significant Differences	5%	7.4	.93	2.7
		1%	9.9	1.23	3.6

+ Weed control of all plots were rated (1-10) 1 = good weed control, 10 = no weed control.

Table II. Effect of Chemical Herbicides on Yield of Asparagus and on Weed Growth.

	Material	Rate per acre	No. of Treat-ments	Wt. in pounds	Weed Control (1-10)
1	Potassium Cynate	33 lbs.	2	18.9	7.5
2	Exp. Herb. No. 1	5 lbs.	2	22.7	6.0
3	Untreated, Uncultivated		0	22.4	8.5
4	Granular Cyanamid	400 lbs.	1	18.3	6.0
5	Granular Cyanamid	800 lbs.	1	16.8	4.3
6	2,4-D Triethanolamine	2 lbs.	2	16.0	5.3
7	2,4-D Triethanolamine	4 lbs.	2	19.8	4.5
8	2,4-D Triethanolamine	1 lb.	2	15.7	7.5
9	2,4-D Sodium Salt	2 lbs.	2	14.9	5.3
10	2,4-D Sodium Salt	4 lbs.	2	16.8	5.3
11	2,4-D Sodium Salt	1 lb.	2	13.1	7.5
12	2,4,5-T Ortho Ester	2 lbs.	2	16.9	6.8
13	2,4,5-T Ortho Ester	4 lbs.	2	13.3	6.8
14	2,4,5-T Ortho Ester	1 lb.	2	15.2	6.8
15	2,4-D Butyl Ester	2 lbs.	2	18.6	6.8
16	2,4-D Butyl Ester	4 lbs.	2	20.2	3.8
17	2,4-D Butyl Ester	1 lb.	2	17.6	7.8
18	Dow Selective	1 gal.	2	15.2	4.0
19	Dow Selective	2 gals.	2	19.8	3.3
20	Dow Selective	3 gals.	2	16.4	2.3
21	Stoddard Solvent	100 gals.	2	14.4	4.0
	Significant Differences	5%		5.06	2.18
		1%		6.73	2.90

Table III. Effect of Chemical Herbicides on Yield of Peas and on Weed Control.

	Material	Rate per acre	Time of Applica-tion	Yield of Pods lbs.	Wt. of Weeds lbs.
1	Esso Weedkiller 45	50 gal.	Pre-Emer.	28.7	37.3
2	Shell Oil 130	5 gal.	"	25.9	30.1
3	Exp. Herb. No. 1	3 lbs.	"	22.4	34.3
4	ACP 549	1/3 gal.	"	22.5	37.9
5	Nothing	---	---	24.6	59.9
6	Sinox + 100 gal. water	3 qts.	Post-Emer.	24.3	27.3
7	Dow Selective + 100 gal. water	3 qts.	"	26.6	20.7
8	Dow Selective + 25 gal. water	3 qts.	"	24.8	35.0
	Significant Differences	5%		N.S.D.	17.35
		1%			23.61

The Response of Several Vegetables
to Stem-Sprays with Several Herbicides

R. D. Sweet[1], S. L. Dallyn[2]
C. W. Terry[3], and G. M. Taylor[4]

Although selective herbicides have been developed for many field and vegetable crops, there still are a large number of the latter which cannot be selectively weeded. The pre-emergence method has been helpful in some areas and for certain crops but at best it would be considered only as a stop-gap if a selective treatment could be found.

Unpublished work at the Delta Expt. Sta. Stoneville, Miss. by Meek, Wooten, Talley and others has shown that cotton and lima beans are relatively tolerant of low-gallonage stem applications of Stoddard Solvent. With this information as a basis, greenhouse tests of an exploratory nature were undertaken early in 1949 to determine possible additional crop tolerances. These tests indicated that all types of beans, as well as large stem crucifers, and sweet corn probably would be tolerant of stem sprays of several herbicides.

During the growing season of 1949 several field experiments were conducted with the following crops: Cauliflower, broccoli, cabbage, sweet corn, snap beans, lima beans, and field beans.

All field applications were made by means of low-gallonage directional spray equipment* described in detail in another paper presented at these meetings.

For the sake of clarity the several experiments will be presented separately.

Expt. 1--The purpose of experiment No. 1 was to determine the response of beans and weeds to stem applications of several different herbicides. Three 20-foot replications each of snap (Bountiful), lima (Fordhook), and field (Red Kidney) beans were used for each material. Treatments were applied to single rows

*Designed by O. B. Wooten, Jr., Miss. Delta Expt. Sta., Stoneville, Miss. and modified by C. W. Terry, Dept. Agric. Eng. NYS Col. of Agric.

[1]Associate Professor, Department of Vegetable Crops, Cornell University, Ithaca, New York

[2]Graduate Assistant, Department of Vegetable Crops, Cornell University, Ithaca, New York

[3]Professor, Department of Agricultural Engineering, Cornell University, Ithaca, New York

[4]Student Assistant, Department of Agricultural Engineering, Cornell University, Ithaca, New York

which matched end-to-end. Thus a single treatment extended lengthwise along 180 ft. of row. This design facilitated the use of tractor equipment but hampered the interpretation of the yield data. Applications were made July 5, five weeks after planting. At this time the snap beans were in bloom but the other two were not. All were 10-12" tall.

Descriptions and sources of the materials used in the several experiments together with the abbreviations adapted for convenience are given in Table 1.

The rates of herbicide applications were arbitrarily controlled by regulating the volume of spray rather then by changing the concentration.

Details as to actual rates and materials used in the first experiment are presented in Table 2. Although spray rates listed are on an acre basis, they are based on the 8" area actually sprayed. Thus from a practical viewpoint a much smaller quantity of material is needed to cover a crop acre than is given in the Table. For example, when snap beans are in 24" rows, only 1/3 of the area is being sprayed, so that the 3/4 lb/acre DN or the 25 gal/acre Varsol treatments actually require only 1/4 lb. and 8.3 gal. of DN and Varsol respectively.

Results of the experiments with beans are given in Table 2. Stand and weed counts are averages of all three kinds of beans. Only 1 treatment, Varsol #2 at the high rate, 50 gal/A, gave sufficient injury to significantly reduce stand. All others had no measurable effect. A majority of the treatments gave satisfactory weed control. Salt sprays, however, as well as the 2.5 lb/acre PCP in fuel oil treatment were ineffective in reducing weed populations.

Yields were not reduced by any treatment. Likewise time of maturity was unaffected. Statistically, some of the treatments appear to have increased yields over that of the checks. It is questionable that this is due to treatment. Because of the design of the experiment some of the treatments could have had a more favorable location.

Because this method of control is suitable only for small or low growing weeds it was necessary to hand weed all the plots once before treatments were applied. At the time of spraying the second weed crop was well established with most of them still two inches or under in height. The principle weeds present were purslane, lamb's quarters, redroot, knotweed, and nut grass. Twenty-one days later weed counts were taken in all plots. This was done by counting all weeds, regardless of size, in an area eight inches wide and three feet long down each row. Weed populations in some of the treatments were down to as low as ten percent of those in the checks.

Preliminary hand weeding in the row will have to be eliminated if the stem sprays are to be truly successful. There are two possible ways in which this might be accomplished. One is to spray the beans earlier in their growing season. This possibility is discussed later in the paper. The second, and probably the more promising, is to use stem sprays in conjunction with pre-emergence treatments. Materials are available now which will hold weeds back in many crops until the crop itself is well established.

Table 1. Chemicals used as stem sprays.

Abbrev.	Active ingredient	Source
DN	Di-Nitro Secondary ortho Butyl Phenol	Dow Chemical Co..
PCP	Pentachlorophenol(in fuel oil)	Monsanto Chemical Co.
NaPCP	Sodium Pentachlorophenate	Monsanto Chemical Co.
Var. 1	Stoddard solvent(low aromatic)	Standard Oil Development Co.
Var. 2	Stoddard solvent(10-20% aromatic)	Standard Oil Development Co.
Esso #45	High aromatic-kerosene boiling range	Standard Oil Development Co.
Cyanate	Potassium cyanate	American Cyanamide Co.
PCP(CDA-9)	Pentachlorophenol formulated in Esso #45	Standard Oil Development Co.
PCP(CDA-5)	Sodium Pentachlorophnate in Esso #45	Standard Oil Development Co.

Table 2. The Effect of Stem-Applied Herbicides on Weeds & Beans.

Treatments				Bean	Weed Counts		Yield[5]		
No.	Material	Lbs/A	Gal/A	Stand	Total[1]	Transformed[2]	Snap	Field	Lima
1	NaCl	50	25	37.1	49	2.28	154.7	98.3	159
2	NaCl	100	50	30.1	32	1.89	140.7	102.0	149
3	DN	0.75	25	34.6	9	1.13**	157.7	119.3	133
4	DN	1.50	50	30.0	20	1.51*	138.3	93.7	158
5	PCP	5.0[3]	50	28.4	9	1.20**	148.3	87.3	126
6	PCP	2.5[3]	25	29.7	33	1.89	145.7	89.3	148
7	NaPCP	5.0	25	29.3	17	1.43*	117.0	83.3	167
8	NaPCP	10.0	50	27.9	13	1.33**	117.7	74.0	155
9	Varsol 1	--	50	31.9	9	1.17**	152.7	89.3	127
10	Varsol 1	--	25	28.0	12	1.25**	114.3	78.0	127
11	Check	--	--	29.7	54	2.37	123.7	62.3	124
12	Varsol 2	--	50	24.1*	5	0.95**	106.0	62.0	123
13	Varsol 2	--	25	27.0	17	1.33**	122.7	59.0	141
14	Esso #45	--	25[4]	27.1	21	1.55*	126.0	67.3	162
15	Esso #45	--	50[4]	27.0	11	1.20**	117.0	74.3	125
16	Check	--	--	29.0	43	2.11	111.3	62.3	154
	LSD 5%			5.48		0.62	32.7	19.8	Variance non-significant
	1%			7.26		0.82	44.0	26.7	

(1) Total number of weeds in 27 feet of row (9 three-foot rows)
(2) Data transformed for analysis $\sqrt{X + 0.5}$
(3) Formulated in fuel oil.
(4) 2 water: 1 oil
(5) Yield in ozs. per 20 foot row.

Expt. 2--Since the first experiment indicated stem sprays were definitely feasible for beans, a second experiment was designed to determine if frequency and total quantity of spray would influence crop response. Snap beans were chosen for the test crop. Cyanate was substituted for the ineffective salt sprays. Starting at bloom, sprays were applied at intervals of 3 and 5 days. When treatments were terminated, some of the plots had received 4 and others 3 applications.

In contrast to the results in the first experiment where little injury was observed with 1 application, yields in about one half of the treated plots were significantly reduced. As can be seen in Table 3 NaPCP was the only material which did not show a reduction in yield at either or both the 3 and 5 day rates. There was, however, little visible effect of any of the materials on the plants, except with Varsol 2 which reduced the stand about 10%.

Table 3. Effect of several consecutive stem sprays on snap beans.

Treatment[1]	Yield[2]
45 gal/ac 2% cyanate every 5 days	45.5**
45 gal/ac 2% cyanate every 3 days	51.2**
1 lb/ac DN every 5 days	55.2**
1 lb/ac DN every 3 days	66.7
45 gal/ac 2 H_2O: 1 Esso #45 every 5 days	74.3
45 gal/ac 2 H_2O: 1 Esso #45 every 3 days	56.5*
Check	80.0
45 gal/ac Varsol 2 every 5 days	69.5
45 gal/ac Varsol 2 every 3 days	46.0**
7.5 lb/ac NaPCP every 5 days	71.8
7.5 lb/ac NaPCP every 3 days	67.5
4 lb/ac PCP(CDA-9) every 5 days	53.0**
4 lb/ac PCP(CDA-9) every 3 days	62.2

Expt. 3--Crucifers and corn were sprayed with the following materials: NaPCP at 7.5 lbs/acre, PCP 4 lbs/acre, cyanate 2%, DN 1 lb/acre, Varsol #1, and Esso #45--2 water: 1 oil. All treatments were applied at the rate of 45 gallons per acre.

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[1]Carried out on snap beans--sown July 5. First application Aug. 8, beans just starting to bloom. The 3-day rows were sprayed 4 times, 5-day rows 3 times in a period of 12 days. There was little visible effect of any of the materials on the plants except with Varsol #2 which killed about 10%.

[2]Yield in ozs. per 20 foot row.

The crucifer plots consisted of one 12-plant row for each crop. There were three such replicates for each treatment. The corn plots were single 20 foot rows, with four replicates per treatment.

The crucifers were planted June 24 and set in the field four weeks later. Treatments were applied on August 19. Observations taken on August 27 indicated only very superficial injury to the plant stems. Golden Cross corn was sown July 6 and was sprayed twice, once at six weeks of age when the plants were about three feet tall, and the second time one week later. Weed control was similar to that in experiment one.

As was the case with the one-spray treatments of beans, there was no significant reduction in yield. With corn, however, there was an increased amount of lodging in the Varsol plots.

In addition to the above experiments, an attempt was made to determine the effect of age of crop plant on spray tolerance. Due to the dry weather conditions which prevailed in Ithaca in 1949 very few satisfactory data were obtained.

Snap beans of three different ages, 12 days between each, were sprayed with Varsol 1, Esso #45, Na PCP, & DN at 45 gal/acre. At the time of treatment the older plants were just starting to flower, those in the second lot were 6-8 inches high, and in the third 3 inches tall with the first true leaves just formed. The younger plants were considerably more sensitive and more difficult to treat without getting the spray on some of the leaves. Nevertheless about 90% of the stand survived and reached maturity. A similar experiment with corn indicated that age may be more important in this crop. Further study is needed before much can be said on this point.

Discussion. Most, if not all, of the sprays giving satisfactory weed control caused some damage to the crop where the material hit the stems. With beans and crucifers the epidermis was killed and turned mahogany brown in color. In most cases this dead tissue penetrated no further than the phloem, often not even that deep. Heavy applications of the oils, especially Varsol on beans, sometimes went all the way through, killing the stem and allowing it to snap off. Usually, however, not more than 25% of the phloem was destroyed and none of the interior tissues damaged. The seriousness of such phloem destruction may depend on the stage of growth at which it occurred. In older plants it would be expected to be less harmful, perhaps might even be slightly beneficial; in young plants it could be quite serious. With corn the outer sheath tissues became bleached but, with the exception of the Varsol treatments, did not appear to be particularly serious.

Stem damage was accentuated by the relatively high gallonage rates used. Sufficient spray often hit the stem so that it ran down and collected at or just below the soil surface. In practically every case the most severe injury was just below the ground level. It is thought that this can be readily corrected by decreasing the gallonage. It is probable that both the amount of herbicide and volume of spray can be considerably reduced and still obtain satisfactory weed control.

Since the principle of stem application is to apply the spray material close to the ground, it is obvious that the weeds must be small at the time of treatment otherwise they escape serious injury in the same manner as do the crop plants. An exception to this is found in the case of grasses sprayed with oil. Even when the grass is 6-8 inches tall an application of oil on the lower part of the stems seems to penetrate and seriously affect them. Creeping weeds such as portulaca (purslane), and knotweed are particularly vulnerable since practically their whole surface can be covered even on plants several weeks old.

Summary

From preliminary studies with several vegetables it appears that chemical weeding by means of stem sprays with any one of several herbicides is feasible. Considerable work needs to be done however to determine proper dosages, timing, best chemicals, crop tolerances, etc.

Weeding Corn With Chemicals II*

By William H. Lachman
Massachusetts Agricultural Experiment Station
Amherst, Massachusetts

Many farmers are now spraying their corn fields with 2,4-D for the control of weeds. The merits of this practice were summarized in a previous paper (7). Recently the use of other chemicals have also been suggested as having value for controlling weeds in corn (1, 2, 3) and the purpose of this paper is to present the results of experiments using several of these methods in 1949.

Materials and Methods

Twenty three treatments were applied to North Star sweet corn and these were replicated four times. The plots consisted of four 24-foot rows each and the corn 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 an impervious subsoil and was considered to be low in fertility. It was prepared in the normal manner and a 5-8-7 fertilizer was broadcast at the rate of 2000 pounds per acre. The corn was planted on May 14 which is the average date for the last spring frost in this locality.

The sodium salt of 2,4-D, as 95 percent sodium dichlorophenoxyacetate monohydrate, was applied at the rate of 1.5, 2.0 and 3.0 pounds, acid equivalent, per acre one day after planting and also seven days after planting to a second series of plots. Other treatments were applied at their respective acreage rates one day after planting, as follows: 400 pounds of Granular Cyanamid; 10, 20 and 30 pounds of sodium pentachlorophenate in Dowicide G; 1.5, 2.0, 3.0, 6.0 and 9.0 pounds of dinitro-o-sec-butylphenol (DNOSBP) in Dow General Weed Killer; 1.5, 3.0, 6.0 and 9.0 pounds of the ammonium salt of dinitro-o-sec-butylphenol (A-DNOSBP) in Dow Selective Weed Killer; a mixture of 1.0 pound, acid equivalent, of the sodium salt of 2,4-D and 10 pounds of sodium pentachlorophenate; and 5.0 and 10.0 pounds of diethyl xanthogen disulphide (Sulfasan) in Sherwin Williams' XP-40A Pre-emergence Weed Killer.

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

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The various chemicals used in these experiments were kindly submitted by the following: American Cyanamid Company, Dow Chemical Company and Sherwin-Williams Company.

*Contribution 747 of the Massachusetts Agricultural Experiment Station.

and the speed 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 more or less uniformly throughout the experimental area: purslane, shepherd's purse, smartweed, lamb's quarters, pigweed, galinsoga and wiregrass. A rather sparse and variable stand of nutgrass was present and because of the variable stand this weed was not included in the weed counts which were made on June 16.

All of the plots were cultivated and hand hoed on June 17 and were also cultivated twice later. The advisability of cultivating weed-free plots is rather controversial but has been advocated by some workers as pointed out in a previous paper (7).

Results and Discussion

The results of these investigations are presented in Table I. It is readily apparent that large and significant differences exist among the various treatments in regard to their capacity for controlling weeds. It is interesting too that there were no significant differences in germination of the crop resulting from any of the treatments. Under the conditions of these tests it is evident that XP-40A and Cyanamid were of practically no value for weed control although previous work in New Jersey indicated that 400 pounds of Cyanamid reduced weeds significantly (3). Cyanamid was effective in promoting some nitrogen stimulation resulting in somewhat larger plants that were darker green in appearance and these plots were among the highest yielding in the test.

The 2,4-D treatments reduced the stand of weeds significantly and suppressed development of those that were present to a marked extent but the results were nowhere near as spectacular as in the 1948 experiments (7) where plots with a six-day delayed application of 2.0 pounds of 2,4-D had only 7 weeds as compared to some plots with 43. The seven-day delayed application was superior to the one-day delayed application in so far as weed control was concerned but there was an apparent tendency toward increased crop damage by the former treatment. Pre-emergence applications of 2,4-D on corn resulted in no malformation of crop plants in 1948 (7), but this effect was particularly marked in these tests. As noted on June 24, the one-day delayed 1.5, 2.0 and 3.0 pound 2,4-D treatments produced an average of 9.3%, 11.5% and 22.6% malformed plants; respectively while the 7-day delayed 1.5, 2.0 and 3.0 pound 2,4-D treatments produced an average of 12.3%, 17.5% and 34.5% malformed plants respectively. Thus, under the conditions of these tests it appears that the delayed application had a tendency to produce a greater proportion of malformed plants and with increasing severity in relation to dosage. Results in Table I also display this tendency under the Apparent Crop Damage Column.

Table I - Effect of Chemicals on Weed Control and on Damage, Growth and Yield of North Star Sweet Corn

Treatments Rates per Acre	Number of Weeds per Square Foot June 15	Weed Size Rated 1-10	Apparent Crop Damage Rated 1-10	Average Height of Corn in 4th Replicate (Ins.)	Marketable Ears (Pounds per Plot)
Applied 1 day after planting					
Cyanamid					
400 pounds	53	9.3	1.0	11.0	30.4
XP - 40A					
5.0 pounds	58	9.5	1.0	10.0	23.3
10.0 pounds	52	9.3	1.0	11.0	27.0
2,4-D, Sodium Salt					
1.5 pounds	21	3.8	2.8	9.0	25.2
2.0 pounds	19	4.7	4.5	7.0	21.5
3.0 pounds	23	4.0	7.5	7.0	16.2
Sodium pentachlorophenate					
10.0 pounds	27	3.0	2.0	8.5	27.6
20.0 pounds	8	1.8	2.8	9.0	29.7
30.0 pounds	6	1.5	2.5	9.0	31.9
Dow General					
1.5 pounds DNOSBP	38	5.8	2.0	10.0	29.8
2.0 pounds DNOSBP	28	4.2	2.2	9.0	27.9
3.0 pounds DNOSBP	30	2.5	2.2	9.0	28.9
6.0 pounds DNOSBP	10	1.8	4.5	9.0	26.9
9.0 pounds DNOSBP	7	1.0	5.5	8.0	26.2
Dow Selective					
1.5 pounds A-DNOSBP	38	5.3	2.7	8.0	29.7
3.0 pounds A-DNOSBP	34	3.5	3.8	9.0	28.8
6.0 pounds A-DNOSBP	16	2.0	3.5	9.0	27.6
9.0 pounds A-DNOSBP	6	1.0	4.8	8.0	26.6
2,4-D + Sodium pentachlorophenate					
1 pound 2,4-D + 10 pounds Na PP	23	3.0	4.0	7.5	26.4
Applied 7 days after planting					
2,4-D Sodium Salt					
1.5 pounds	13	3.7	4.3	8.5	24.2
2.0 pounds	14	2.5	6.3	6.0	18.7
3.0 pounds	9	2.0	9.0	6.0	16.1
Control	46	3.7	1.0	11.0	26.2
L.S.D. 5 percent	4.9	1.2	1.6	-	5.5
1 percent	6.5	1.9	2.1	-	7.2

-3-

The figures also indicate that applications of 2,4-D in excess of two pounds are not warranted where it is used as a pre-emergence herbicide on corn because of its depressing effect on yield. It is interesting to note that plots treated with 2,4-D are among the lowest yielding in these tests. It appears that soil and season, however, limit wide-scale recommendations as evidenced by results of Hamner et al (6) where 5 pounds of 2,4-D in pre-emergence applications apparently did not cause damage. Recommendations from New Jersey indicate that it is safe to spray corn with one pound of 2,4-D until the corn is two inches high (5).

Some of the earlier work indicated that sodium pentachlorophenate was of value in certain crops as a selective herbicide but it is now finding its greatest possibilities in pre-emergence applications (1, 2, 4, 8). In these experiments, sodium pentachlorophenate was particularly noteworthy in its ability to control weeds with a minimum of damage to the crop. It appears that about 20.0 pounds of this chemical would be about the optimum application when balancing the results with the item of expense. Plots treated with 20 pounds of sodium pentachlorophenate had an average of only 8 weeds per square foot and these weeds were very small. Apparent crop damage was relatively slight and yields were among the highest in the test.

The dinitro treatments were very effective in controlling weeds at the 6.0 and 9.0 pound application rate but crop damage was greater, yields had a tendency to be lower on these plots and cost of material is rather high. Results from the DNOSBP treatment and the ammonium salt of this compound appeared to be comparable on a pound for pound basis.

The mixture of 2,4-D with sodium pentachlorophenate was not particularly outstanding in controlling weeds or in other respects. There is no hint of any synergistic action with these chemicals at the concentrations employed. There were 3.6% of the corn plants malformed on these plots, resulting from the 2,4-D present in the mixture.

Summary

Pre-emergence applications of 2,4-D produced seriously malformed corn plants, and yields were reduced significantly with a 3.0 pound application of this material. A 400 pound application of Granular Cyanamid and 5.0 and 10.0 pound applications of XP-40A were not effective in controlling weeds. Sodium pentachlorophenate, DNOSBP and the ammonium salt of DNOSBP were very effective pre-emergence herbicides.

Results of this investigation indicate that about 20 pounds of sodium pentachlorophenate applied soon after planting was the most effective treatment under test. It appears that this technique deserves considerable attention in planning further investigation concerned with weed control practices in corn.

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Chemical Control of Wild Mustard

in Canning Peas and its Effect on Productivity

C.H. Dearborn[1]

Wild Mustard is the most common weed occurring in canning pea acreages in New York State. In some of the pea growing areas the stand of mustard is so thick that pea yields are materially reduced by the competition of the weed. Under these conditions numerous good pea growers have omitted peas from their rotation but have not solved their weed problem since mustard is also troublesome in their spring grains. The canner also has a stake in this matter because the mustard increases the tonnage of green material to be vined by as much as 30 to 50 per cent and consequently increases the vining time per ton of shelled peas obtained.

Selective weeding of peas with Sinox was proposed by Westgate and Raynor (3) and more recently the use of dinitro compounds for weeding peas has been recommended by Raynor (2) and Barrons and Grigsby (1). Results of preliminary studies made by workers in the Vegetable Crops Department of Cornell Experiment Station, Ithaca, N.Y. indicated that severe burning of pea foliage frequently occurred when the dinitro compounds were used in accordance with recommendations issued for other regions.

The purpose of this study was to determine if a suitable material was available for weeding canning peas.

Materials and Methods

Screening test for selective weed killers for peas was begun in the greenhouse in 1947. Peas showed a tolerance to sprays of concentrated sodium chloride, sodium nitrate, a mixture of the two salts, Sinox-W, Dow Selective Weed Killer and to Aero Cyanamid dust, whereas mustard (Brassica arvensis) was effectively controlled.

Field experiments were conducted in 1947, 1948, and 1949 to determine the effectiveness of these and other products on the control of weeds particularly wild mustard in several varieties of canning peas. In the 1947 study all materials were applied with hand operated equipment, whereas in 1948 the sprays were applied from a tractor-mounted spray boom which gave complete coverage of a 12 foot strip. Spraying System Company nozzles were mounted on the boom 18 inches apart and were calibrated at 50 pounds pressure except for the concentrated salt sprays where only 20 pounds pressure was used. The cyanamid dust was applied with a self-propelled power duster. In all cases only one application of the spray or dust was made.

In 1948 the plots were 25' X 200' and arranged in a parallel series. All treatments were applied when the peas were 4" to 8" tall. At this time the mus-

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[1]Assistant Professor Vegetable Crops. Contribution from Division of Vegetable Crops. Journal Paper No. 808 of the New York State Agricultural Experiment Station published with the approval of the Director.

tard was in the fourth true-leaf stage. Climatic conditions were cloudy, cool and wet prior to, during, and after treatment.

When the peas were prime for canning, the vines in each plot were cut with a sickle from within two frames 3' X 9' each. A small portable viner was used for threshing the peas from the vines. Records were taken on the total weight of green matter cut per plot and on the weight of mustard plants after separating the weeds from the pea vines. Tenderometer readings were also obtained on each sample of shelled peas. Yield records were based on the average weight of shelled peas obtained from the two 27 square foot samples in each of the 5 replicates. The method of analysis of variance was used in interpreting the data from all experiments.

The procedure for 1949 differed from the above in that 1. All plots were 12' X 30' arranged in the latin square design where possible, 2. Aero cyanate spray was used at 8, 10, 12, and 14 pounds in 25 or 75 gallons of water per acre; 3. Dinitro (Dow Selective) was used at 7 pints in 25 or 75 gallons of water per acre, 4. The two sprays, sodium chloride and the mixture of sodium chloride and sodium nitrate were applied at 160 gallons of water per acre or just double that used previously, 5. The amine salt of 2,4-D was used at 1/4 of a pound acid equivalent per acre, 6. All sprays were applied at 35 pounds pressure from a bank of spray booms fed by separate pumps, 7. Low temperatures and dry weather prevailed prior to, during, and for several days after each experiment was sprayed, 8. The pea sample for vining was taken from a 45 square foot area by placing 3 frames 3' X 5' each, end to end yet off-set by their width so that a diagonal pattern was obtained, 9. The tricycle type tractor ran over the peas after the spray was applied and also over the unsprayed checks.

Results

The 1947 field studies indicated that the spray pattern of the hand operated sprayer varied with the operator and was not uniform enough for testing the weedicidal value of selective weedicides. In 1948 five treatments were well randomized and replicated five times in a commercial planting of Thomas Laxton

Table 1. Effect of weedicides on yield and maturity of peas and on growth of mustard.

Treatment	Rate Per Acre		Mustard	Yield	Tender-
	Chemical	Water	Tons / Acre*	Lbs. Per Acre	ometer Reading
1. Dow Selective	7 Pts	70 Gal	0.0	3090	115
2. NaCl	160 Lbs	80 "	3.5	2580	110
3. NaCl & $NaNO_3$	128 & 96	80 "	3.0	2450	110
4. Aero Cyanamid	75 Lbs	Dust	2.6	2300	107
5. Check	---	---	5.5	2490	107
L.S.D. 5% Level			1.3	485	3.8

* Weight records taken to the nearest 1/4 pound from plots 27 square feet in extent.

peas. The treatments and rates were 1. Ammonium dinitro ortho secondary butyl phenate (Dow Chemical Co. formulation, 7 pints in 70 gallons of water per acre as recommended by the manufacturers)[2]; 2. Sodium chloride 160 pounds in 80 gallons of water per acre; 3. Sodium chloride 128 pounds plus sodium nitrate 96 pounds in 80 gallons of water per acre; 4. Aero Cyanamid dust 75 pounds per acre; and 5. No Treatment. Yield records and tenderometer reading for the 5 treatments are presented in Table 1 together with the tonnage of mustard produced.

The data show that the average yield of shelled peas taken from the Dow Selective spray treatment was 3090 pounds per acre as compared to 2490 pounds on the untreated plots. The statistically significant increase in yield becomes even more significant from the practical standpoint when it is noted that there was an average of 5.5 tons of mustard per acre on the untreated area and practically none on the plots sprayed with dinitro compound. Each of the other treatments reduced the tonnage of mustard significantly below that of the check without affecting the yield of peas. Undoubtedly some compensation should be made for the fact that the higher, earlier yields are associated with the higher tenderometer readings. Large scale testing of Aero Cyanamid by airplane showed that an excellent job of mustard control could be obtained if 75 to 100 pounds of the dust was applied per acre when the peas and weeds were wet with dew and while the mustard was in the 2 true-leaf stage of growth. Some burning of the pea foliage occurred but the damage appeared rather insignificant.

Table 2. Effect of 4 weedicidal materials on the productivity of peas and control of mustard.

Treatment	Materials Rate /A	Gals. of Water /A	Shelled Peas Lbs. /A	Mustard Tons /A
1. Aero Cyanate	8 Lbs	25	800	0.5
2. " "	10 "	25	1070	-
3. " "	12 "	25	1030	-
4. " "	14 "	25	1120	-
5. " "	10 "	75	950	-
6. " "	12 "	75	1220	-
7. " "	14 "	75	950	-
8. Dow Selective	7 Pts	75	1220	-
9. Sodium Chloride	320 Lbs	160	1350	-
10. Sodium Chloride	256 "			
& Sodium Nitrate	192 "	160	1070	-
11. Check	No Treatment		290	1.5
L.S.D. - 5% Level			520	

In 1949 six experiments were conducted with 4 canning pea growers who normally had a heavy stand of mustard. Three experiments dealt with pre-emergence weeding practices but did not result in satisfactory mustard control and are not reported herein. Experiment I consisted of 3 replicates of 11 treatments de-

[2]The author is grateful to the Dow Chemical Co., Midland, Michigan for providing an ample supply of chemical with which to work.

signed to gain information on how to use Aero Cyanate[3] for mustard control in peas. The treatments used and the yields obtained are presented in Table 2.

It is evident from the 1/2 ton of mustard cut per acre that 8 pounds of Aero Cyanate per acre was not enough to kill the mustard under the conditions of this experiment. This conclusion was also supported by field observation. Even though the yields on all treatments were very low, it is obvious that the extremely low yield of 290 pounds of peas per acre on the check plot was largely the result of the competition from the 1.5 tons of mustard growing in the same area. Yield differences were not significant between treatments that gave satisfactory mustard control. It seems pertinent to point out that a large portion of the pea acreage in New York failed in 1949 as a result of low rainfall, high temperatures and a high evaporation rate.

Experiments II and III were laid out on a 7' X 7' latin square design. It developed that mustard was not a problem in Experiment III. Medium red clover was sown with the peas at this location as is the practice in some regions. In Table 3, the treatments for the two experiments are shown as well as the yield of peas, yield of mustard and per cent of clover stand remaining at pea harvest.

Table 3. Yield of shelled peas and tonnage of mustard produced on sprayed versus non-sprayed peas.

	Rate Per Acre		Var. - Surprise Experiment II		Var. - Pride Experiment III	
Treatment	Chemical	Gals. of Water	Lbs. /A Shelled Peas	Tons /A Mustard	Lbs. /A Shelled Peas	PerCent Clover Remaining
1. Dow Selective	7 Pts	25	1460	0	1920	15
2. Dow Selective	7 "	75	1470	0	1940	50
3. Aero Cyanate*	12 Lbs	25	1740	0	1700	30
4. Aero Cyanate*	12 "	75	1610	0	1640	15
5. Sodium Chloride	320 "	160	1590	0	1510	0
6. Sodium Chloride	256 "					
& Sodium Nitrate	192 "	160	1610	0	1430	5
7. Check	No Treatment		1160	2.7	1470	100

Difference not significant at the 5% level.
* Aero cyanate in Experiment III used at 14 lbs. per acre

Statistically, the average yield of shelled peas per plot for the seven treatments were not significantly different.

It is of interest however that in both experiments the yield of peas from the sprayed plots was generally higher than from the checks. Where mustard was present any one of the 6 chemical sprays gave satisfactory control. It is of practical significance that where a chemical spray was applied no measurable

[3]The writer gratefully acknowledges the cooperation of Dr. D.S. Fink and the American Cyanamid Co., 30 Rockerfeller Plaza, N.Y.C., N.Y. for advice, chemicals and financial assistance in the form of a grant.

quantity of mustard persisted whereas the check areas in Experiment II produced mustard at the rate of 2.7 tons per acre.

The limited nature of the 2,4-D study with mustard control in peas indicated that pea yields were not adversely affected by 1/4 of a pound per acre of the triethanolamine salt of 2,4-D. Application made when the peas were breaking ground and up to 2 inches tall gave excellent control of mustard and all other weed seedlings that were sensitive to 2,4-D. Where the tractor wheels crushed the pea plants after spraying, the peas showed the typical plant response to a non-lethal dosage of 2,4-D. In this connection yield records in other experiments were not significantly different in the untreated plots between samples drawn from areas including the wheel tracks and from similar areas outside the tracks. Similar samples drawn from the sprayed plots indicated a tendency for higher yields outside the tractor tracks but the differences did not approach significance at the 5% level.

Throughout these studies weeds other than mustard common in this region were encountered. All were satisfactorily controlled except Lambs quarters (Chenopodium album) growing on the plots sprayed with salt or salt plus sodium nitrate. The saline sprays are not satisfactory selective weedicides where Lambs quarters is the predominant weed.

Summary

The results of these studies show that mustard can be satisfactorily controlled in canning peas in New York with Dow Selective weed killer, Aero Cyanate, Aero Cyanamid, sodium chloride and sodium chloride plus sodium nitrate without adversely affecting the yield of shelled peas. In areas where water is not plentiful Aero Cyanate or Dow Selective weed killer may be dispersed over an acre of peas with as little as 25 gallons of water. Workers in this field express the belief that the lower gallonage results in greater foliage burn to the peas. The writer concurs in this general belief. However, the growing points of the peas were burned off more often with the higher gallonage because the spray particles coalesced at the axils of the pea leaves.

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Chemical Weed Control in Potatoes*

Ora Smith, E. R. Marshall and M. W. Meadows[1]

This report is a continuation of the work reported at this Conference last year under the title of "Control of Weeds in Potatoes with Chemicals."

Experiment I

Potatoes of the Sebago variety were planted in sandy loam soil April 22, 1949. One hundred treatments were made in duplicate on plots 6 feet x 6 feet 10 inches on May 16, 1949 shortly before emergence of the potatoes. Total gallons per acre applied varied from 40 to 100. This was considered as a screening test for various chemicals and combinations of chemicals on weed control. Triethanolamine salt of 2,4-D was used throughout these experiments. Results of some of the most promising chemicals are presented in the following tables.

Table 1. Effect of Chemicals on Weed Growth in Potatoes

Chemical and amount		Number of weeds and grass in 2 sq. ft. (June 29) NaPCP 10 lbs.	NaTCA 10 lbs.	ATHC 25 lbs.	2,4-D 1 lb.	HAN 132 10 gal.	Untreated
NaPCP	10 lbs.	5	2	-	0	5	-
NaTCA	10 lbs.	2	33	5	0	37	-
ATHC	25 lbs.	-	5	4	1	10	25
2,4-D	1 lb.	0	0	1	0	-	-
HAN 132 10 gal.		5	37	10	-	-	-
Untreated		-	-	-	-	-	46

NaPCP = sodium pentachlorophenate; NaTCA = sodium trichloroacetate; ATHC = ammonium thiocyanate.

*Paper No. 328. Department of Vegetable Crops, Cornell University

[1]Professor of Vegetable Crops and Graduate Assistants in Vegetable Crops, Cornell University, Ithaca, N. Y.

Table 2. Effect of 2,4-D in Combination with Other Chemicals on Weed Control.

Chemical and amount per acre	Number of weeds and grass in 2 square feet (June 29) One pound 2,4-D per acre Weeds	Grass
1 pint Sinox G. ≠ 10 gal HAN 132	0	1
2 lbs. NaPCP ≠ 5 gal. " "	1	1
5 lbs. NaPCP ≠ 10 gal. " "	0	1
2 lbs. PCP ≠ 10 gal. " "	0	1
4 lbs. PCP ≠ 10 gal. " "	0	0
5 lbs. NIX ≠ 10 gal. " "	0	0
1 gal. ATCA ≠ 10 gal. " "	1	0
2 pints Sinox G. ≠ 5 gal. " "	0	1
125 lbs. ATHC ≠ 10 gal. " "	0	2
4 lbs. PCP ≠ 20 gals. diesel	1	1
2 pints Sinox G. ≠ 5 gals. diesel	0	1
	Without 2,4-D	
5 gals. Shell Weedkiller 130	4	6
1/3 gal. K1131 ≠ 15 gals. HAN 132	2	3
1/2 gal. K1131 ≠ 6 gals. diesel	1	3
1/2 gal. K 1131 ≠ 3 lbs. $(NH_4)_2SO_4$	0	4
10 lbs. NIX ≠ 10 gal. HAN 132	21	10
2½ pints Dow G. ≠ 6 gal. diesel	6	9
7½ lbs. Sulfasan ≠ 7½ lbs. NaPCP	1	4
3 gals. Dow Contact ≠ 3 gal. diesel	7	17
Untreated	40	6

Sinox G. = Sinox General; PCP = pentachlorophenol; NIX = sodium isopropyl xanthate; ATCA = ammonium trichloroacetate; Dow G. = Dow General.

Table 3. Effect of Several Weedkillers on Control of Weeds in Potatoes.

Combined with	Number of weeds and grass in 2 sq.ft.(June 29) CDA 3	CDA 4	CDA 5	CDA 9	
Low rate					
alone	24	18	29	15	
5 gal. Esso W.K. 45	16	19	17	24	
10 gal. " " " "	18	25	22	16	
5 gal. Esso No. 2 fuel	10	24	47	22	
10 gal. " " " "	20	34	21	15	
High rate					
alone	18	11	10	17	
5 gal. Esso W.K.45	22	9	9	21	
10 gal. " " "	14	13	14	9	
5 " Esso No. 2 fuel	13	15	24	28	
10 " " " " "	11	26	4	20	
Untreated	--	--	--	--	46

CDA series contain pentachlorophenol or sodium pentachlorophenate with an oil and emulsifier.

Wherever 2,4-D was applied either alone or in combination with other materials, control of weeds and grass was very good. As in 1948, the pentachlorophenols, pentachlorophenates and dinitro compounds resulted in excellent control of broadleaved weeds. Grasses were not present in this experiment to an extent that reliable data on grass control could be obtained.

Experiment II

Green Mountain potatoes were planted in sandy loam soil June 8, 1949 and chemicals for weed control were applied June 22 before emergence of the potatoes. All sprays were applied at the rate of 50 gallons to the acre. Plots were four rows wide and 30 feet long replicated four times. There were 30 treatments. All plots were cultivated once several weeks after the herbicides were applied. Yields of potatoes from these plots are presented in table 4.

Table 4. Effect of Weed Control Methods on Potato Yields

Chemical and amount per acre	yields (bushels per acre) U.S. No. 1	Total
K1131 1/3 gal. + 15 gal. HAN 132	304	349
XP 40 A 2 gal.	276	318
K1131 1/2 gal. + 3 lbs. $(NH_4)_2SO_4$	268	308
Sinox General 2 pints + 15 gal. HAN 132	254	301
NaPCP 5 lbs. + 2,4-D 1 lb. + 10 gal. HAN 132	252	300
PCP 4 lbs. + 2,4-D 1 lb. + 10 gal. HAN 132	254	299
Sinox General 2 pints + 2,4-D 1 lb. + 5 gal. diesel	250	297
NaPCP 2 lbs. + 2,4-D 1 lb. + 5 gal. HAN 132	257	296
PCP 4 lbs. + 2,4-D 1 lb. + 20 gal. diesel	253	292
K1131 1/2 gal. + 6 gal. diesel	251	285
NaPCP 20 lbs.	239	279
NIX 5 lbs. + 2,4-D 1 lb. + 10 gal. HAN 132	229	278
Sulfasan 10 lbs. + 5 gal. HAN 132	230	274
Penite 6,1 gal. + 2 lbs. NaPCP	223	270
No treatment	220	268
Sinox General 1 pint + 2,4-D 1 lb. + 10 gal. HAN 132	216	262
Sinox General 2 pints + 2,4-D 1 lb. + 5 gal. HAN 132	210	259
NaPCP 10 lbs. + 1 lb. 2,4-D	221	259
NaTCA 10 lbs. + 10 lbs. NaPCP	212	256
PCP 7 lbs. + 10 gal. HAN 132	215	252
Sulfasan 12½ lbs. + 7½ lbs. NaPCP	212	251
ATCA 1 gal. + 2,4-D 1 lb. + 10 gal. HAN 132	200	240
ATHC 25 lbs. + 1 lb. 2,4-D	197	238
Penite 6, 1 gal.	198	237
NaTCA 10 lbs. + 1 lb. 2,4-D	181	221
ATHC 12½ lbs. + 2,4-D 1 lb. + 10 gal. HAN 132	159	202
ATHC 25 lbs. + 10 gal. HAN 132	165	200
ATHC 25 lbs.	145	190
ATHC 25 lbs. + 10 lbs. NaTCA	133	169
ATHC 37 lbs.	137	168
L. S. D. at .05	69	71

Table 4. (Continued)

NaPCP = sodium pentachlorophenate; PCP = pentachlorophenol;
NIX = sodium isopropyl xanthate; NaTCA = sodium trichloroacetate;
ATCA = ammonium trichloroacetate; ATHC = ammonium thiocyanate.

There were very few weeds in any of the plots, no significant differences existed between the weed counts of the plots.

Experiment III

Potatoes of the Green Mountain variety were planted in sandy loam soil May 30, 1949 and preemergence application of herbicides was made on June 15 with a 4-row boom mounted on a jeep. Sprays were applied at the rate of 35 gallons to the acre. Normally cultivated plots were compared with those to which herbicides were applied but with no cultivation.

Table 5. Effect of Chemical Weed Control Methods on Yields.

Chemical and rate per acre	Total yield, bushels per acre
sodium trichloroacetate, 20 lbs.	361
normal cultivation	406
2,4-D 2 lbs.	501
Sinox General 3 pints + 6 gal. diesel	505
sodium pentachlorophenate 20 lbs.	523
sodium pentachlorophenate 10 lbs. + 10 gal. diesel	568

Control of weeds and grasses in all treatments except sodium trichloroacetate was almost perfect.

Experiment IV

Potatoes of the Sebago variety were planted May 30, 1949 in a silt loam soil in an area infested with quack grass. Several herbicides were applied through knapsack sprayers on June 29 when the plants were about 8 inches tall by protecting the plants from the direct application of the spray. The entire area had received one cultivation previous to spray application. Results on yields are as follows:

Table 6. Effect of Herbicides on Yields of Potatoes.

Chemical and rate per acre	Total yield, bushels per acre
sodium trichloroacetate, 20 lbs.	436
sodium pentachlorophenate, 20 lbs.	490
Untreated	554
Sinox General 3 pints + 6 gal. diesel	574
ammonium thiocyanate 35 lbs.	581
normal cultivation throughout season	590
sodium pentachlorophenate 10 lbs. + 1 lb. 2,4-D	640

Control of weeds was good in all of the herbicide-treated plots. Control of quack grass in all herbicide-treated plots was better than in the plots cultivated only once and as good as the normally cultivated plots. Sodium trichloroacetate stunted the quack grass to such an extent that none could be seen without searching for it under the sprawling vine growth.

SUMMARY

1. Preemergence application of 2,4-D at rates of one to two pounds to the acre afforded excellent control of broadleaved weeds in potatoes with no decrease in yields of potatoes.

2. Pentachlorophenol, sodium pentachlorophenate and several forms of the dinitro compounds controlled weeds to a high degree when applied either alone or in combination with other materials such as HAN 132, 2,4-D or diesel oil.

3. Several other chemicals resulted in good control of weeds but also decreased the yields of potatoes. This was particularly true of sodium trichloroacetate and ammonium thiocyanate.

WEED CONTROL IN POTATOES ON LONG ISLAND[1]

J. Howard Ellison and Walter C. Jacob

Much interest has developed concerning chemical weed control in potatoes. This is natural, for in many ways the Irish potato lends itself favorably to chemical weeding.

Although no selective herbidide has yet been found which will control weeds among potato plants without injuring the crop, the technique known as pre-emergence application of herbicides has been used with very good results under some conditions. The potato seed piece contains a large reserve of food material and from it comes a strong shoot to develop above ground -- two factors definitely in favor of a crop which is to be chemically weeded by the pre-emergence technique. In addition to this, the potato is relatively resistant to chemical injury in comparison with many other crops.

Two possible advantages of chemical weeding of potatoes are the reduction of cultivation costs to the farmer, and the reduction of traffic of heavy equipment in the field. The object of this study was to test several chemicals, each at three rates, to determine their relative merits as pre-emergence herbicides in potatoes, with and without a post-emergence oil spray, and with and without one midseason cultivation. Normal cultivation was used as a standard by which to judge the above treatment combinations.

MATERIAL AND METHODS

Two similar experiments were conducted in a field of Katahdin potatoes, which were planted April 5, 1949 in 34 inch rows and fertilized with 2500 pounds of commercial 5-10-5 fertilizer. Experiment number one consisted of the following treatments: Shell 130 at 5, 7.5 and 10 gallon per acre; sodium pentachlorophenate at 10.5, 14 and 17.5 pounds per acre; Sinox General at 2 pints plus 4 gallons of kerosene, 3 pints plus 6 gallons of kerosene and 4 pints plus 8 gallons of kerosene per acre; and Penite-6 at 0.5, 1.0 and 1.5 gallons per acre with 5 pints of 40% pentachlorophenol added to each rate of Penite-6. The above chemicals were emulsified or dissolved in water and applied at the rate of 100 gallon of spray per acre on May 4 and 5. A few scattered potatoes were begining to emerge. One series (3 replications) of the above 12 treatments received no further treatment, but another series (3 replications) received a supplementary application of Esso-45 at 35 gallon per acre just a month after crop emergence. The Esso-45 was confined to the middles between the rows of young potato plants. Normally cultivated rows adjacent to either side of the experiment were used as a standard control by which to judge the chemically weeded plots.

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[1] Assist. Prof. and Assoc. Prof. respectively, Cornell Vegetable Crops Department, L. I. Vegetable Research Farm, Riverhead, N.Y.

Experiment number two was identical with number one, except that the Esso-45 oil spray was replaced by a single (tractor) cultivation, randomized on one-half of the basic pre-emergence plots on June 10, five weeks after crop emergence. In both experiments the plot size was 4 rows 21 feet in length, the inner 2 rows being used for record. Each experiment consisted of three replications.

The pre-emergence plots were rated with respect to their weed populations on June 2, before the Esso-45 or cultivation treatments were made. The usual 1 to 9 rating system was used; 1 indicating no weed control and 9 representing perfect control.

On June 23, during the record breaking heat and drought period, soil moisture measurements were made. The comparison desired was between uncultivated plots and adjoining normally cultivated ones. The adjacent plots were paired and from each plot was taken a composite sample consisting of three soil tube borings from the 5 inch to the 9 inch depth levels. The soil samples were obtained between plants in the row. At this time no irrigation had been used. Approximately two weeks later (July 8-9) the entire experimental area was irrigated. The plots were harvested and graded September 20, 1949.

RESULTS

In experiment 1 and 2, Sinox General gave the poorest weed control according to the ratings presented in tables 1 and 3. Sodium pentachlorophenate gave the best control in both tests, Penite-6 plus pentachlorophenol being equally as good in experiment 2. Shell 130 was intermediate in control of weeds.

Table 1. Experiment 1. Weed control rating as influenced by pre-emergence application of various herbicides. (1 = no control; 9 = perfect control) Observations made one month after treatment.

Esso-45	5.2
Sodium pentachlorophenate	7.1
Sinox general	4.9
Penite-6 plus pentachlorophenol	5.9
LSD at odds 19:1	0.9
LSD at odds 99:1	1.3

No significance in weed control was found among rates of application of chemicals in experiment No.1, but in No. 2 the highest mean rate controlled weeds better than the lowest mean rate (see table 3.)

Table 2. Experiment 1. Yield of U. S. No. 1 tubers in bushels per acre as influenced by pre-emergence herbicide application and by normal cultivation.

	Bushels per Acre
Mean of all sprayed plots	53
Mean of normally cultivated plots	181 +

+ Difference is significant at odds 999:1 according to "t" test.

No significant yield differences were found among the various pre-emergence treatments in either experiment 1 or 2. The Esso-45 post-emergence oil spray (Exp. 1) also had no significant effect on yield. However, when the mean yield of U. S. No. 1 potatoes from all the pre-emergence treatments were compared with the mean yield from the normally cultivated plots, the difference was found to be highly significant (see table 2). The normally cultivated plots yielded more than three times as much as sprayed plots.

The same trend regarding cultivation was found in experiment 2. The data in table 4. indicate that plots receiving pre-emergence treatment plus one cultivation yielded significantly more than plots which received the pre-emergence treatment only. Normally cultivated plots yielded four times as much as the uncultivated ones and nearly three times as much as those which were cultivated only once. Needless to say these differences were highly significant.

Table 3. Experiment 2. Weed control rating as influenced by pre-emergence application of various herbicides at various rates of application. (1 = no control; 9 = perfect control) Observations made one month after treatment.

Esso-45		5.7
Sodium pentachlorophenate		6.7
Sinox general		5.2
Penite-6 plus pentachlorophenol		6.7
LSD at odds 19:1		0.6
LSD at odds 99:1		0.8
Rates of application of chemicals	low *	5.7 +
	medium	6.1
	high	6.4
LSD at odds 19:1		0.5
LSD at odds 99:1		0.7

+ Mean of low, medium and high rates for all four herbicides.

Soil samples collected in cultivated and uncultivated plots indicated that a small difference in soil moisture was found in favor of cultivation (see table 5.). The difference was statistically highly significant due to the fact that the results were quite consistant.

Table 4. Experiment 2. Yield of U. S. No. 1 tubers in bushels per acre as influenced by pre-emergence application of various herbicides with and without one cultivation and by normal cultivation.

	Bushels per Acre
Pre-emergence treatment only	49
Pre-emergence treatment plus one cultivation	75 *
Normal cultivation	207 +

* Greater than pre-emergence treatment at odds 999:1.
\+ Greater than either above at odds 999:1.

Table 5. Soil moisture determinations made June 23, 1949 in pre-emergence sprayed plots and in adjoining normally cultivated plots. Each value is the mean of 12 composite samples.

	Percent soil moisture
Pre-emergence plots	8.53
Normal cultivation	9.41 *

* Difference is significant at odds 99:1.

DISCUSSION

Approximately one month after the potatoes were up it was observed that the cultivated plants were larger than the uncultivated ones which had received the pre-emergence sprays. The smaller size of the latter potatoes was not thought to be due to the toxic effects of the chemicals, because the plants in all of the pre-emergence plots looked the same, regardless of which chemical or rate of application was involved. However, positive proof is lacking that chemical toxicity was not involved because there were no plots which were weeded by scraping.

When the difference in plant size was noted the potatoes had been subjected to two or three weeks of unusually hot, dry weather. As the drought persisted during June the cultivated plants continued to grow, whereas the uncultivated ones seemed to stop. Since the lack of water seemed to be the most obvious limiting factor to growth, it was thought that cultivation might have made a difference in soil moisture. Soil Samples indicated that cultivated and uncultivated plots averaged 9.41 and 8.53 percent moisture respectively. It is doubtful, however, that this difference of 0.88 percent moisture was entirely responsible for the larger plant growth, because among the cultivated plots the soil moisture varied as much as ten percent without accompanying differences in plant growth.

Outstanding difference in yields were found between sprayed plots and those receiving normal cultivation, the latter producing three and four times the yield of the former. It is difficult to explain this marked difference, but there is no doubt it is associated with the different methods of weeding and soil tillage.

The single midseason cultivation also produced an unmistakable increase in yield. This points to a response to cultivation which is not complicated by the effect of chemicals, since both the late cultivated plots and the uncultivated ones had the same previous herbicidal treatments.

Table 6. gives climatological data showing the difference in the rainfall and temperature readings for 1947, 1948 and 1949. Weed control experiments on Long Island in 1947 and 1948 produced no such marked differences between chemically weeded and normally cultivated potatoes as was found in 1949. In previous years the normally cultivated plots did tend to yield slightly more than some of the pre-emergence plots, but differences were small. The growing seasons of 1947 and 1948 were in general quite favorable for potatoes, whereas 1949 was not. The very unfavorable yields resulting from chemical weed control in 1949 are associated with an extremely hot, dry season. There is no evidence in the experiment to prove that there is a cause and effect relationship between the hot, dry season and these poor yields. More work will have to be done to determine the factors responsible for the results in 1949.

Table 6. Climatological record at the Research Farm for May through August, 1947, 1948 and 1949.

	May	June	July	August
1947				
Total rainfall	4.25	3.67	2.71	3.76
Departure from normal	--	--	--	--
Mean temperature (F)	57.7	66.0	73.7	73.5
Departure from normal	--	--	--	--
1948				
Total rainfall	6.54	3.93	3.32	0.97
Departure from normal	+3.54	+0.44	-0.16	-3.53
Mean temperature (F)	57.7	66.6	73.8	73.4
Departure from normal	-2.7	-1.6	+0.6	+0.7
1949				
Total rainfall	3.00	0.03	3.17	3.84
Departure from normal	-0.04	-3.46	-0.31	-0.66
Mean temperature (F)	60.2	71.5	77.0	74.4
Departure from normal	+0.4°	+3.3°	+3.8°	+1.7°

RELATION OF CHEMICAL WEED CONTROL IN POTATOES TO OTHER PRODUCTION FACTORS*

Ora Smith, M. W. Meadows and E. R. Marshall[1]

Experimental evidence indicates that weeds can be controlled economically in potatoes with chemicals. The purpose of these studies was to determine what spacing between rows of potatoes and what rates of fertilizer application are best when weeds are controlled with chemicals. These factors have been combined with irrigation.

Experiment I

Green Mountain potatoes were planted on Eastern Long Island April 21 and 22. The following treatments were made:

I. Methods of weed control
  (1) Sinox General 3 pints plus diesel oil 6 gallons per acre
  (2) Wheel hoe
  (3) Normal tractor cultivation (only for 34 inch row spacing)

II. Spacing between rows
  (1) 34 inches
  (2) 17 inches
  (3) 11-1/3 inches

III. Soil moisture level
  (1) not irrigated
  (2) irrigated

IV. Rate of fertilizer application
  (1) 2000 lbs. 5-10-5 per acre
  (2) 3500 lbs. 5-10-5 per acre
  (3) 5000 lbs. 5-10-5 per acre

Sinox General and diesel oil were applied shortly before emergence of the potato plants. Irrigation was made when the grower thought it was needed. A portion of the fertilizer was broadcast before planting and the remainder applied through the planter in bands.

Control of broadleaved weeds and grass with Sinox General was excellent. Yield results are given in the following tables:

Table 1. Method of weed control and yields (average of rates of fertilizer application and spacings).

Method of weed control	Irrigated			Not irrigated		
	U.S. 1	No. 2	Total	U.S. 1	No. 2	Total
Sinox General	374	71	445	350	98	448
Wheel hoe	359	61	420	325	86	411
L.S.D. at .05	N.S.	5.5	N.S.	N.S.	4.8	35.7

*Paper No. 329. Department of Vegetable Crops, Cornell University.

[1]Professor of Vegetable Crops and Graduate Assistants in Vegetable Crops, Cornell University, Ithaca, N. Y.

Table 2. Row spacing and yields (Averages of rates of fertilizer applications and methods of weed control)

Spacing	Irrigated U.S. 1	Irrigated No. 2	Irrigated Total	Not irrigated U.S. 1	Not irrigated No. 2	Not irrigated Total
34 inches	331	37	368	302	54	356
17 "	386	66	452	359	90	449
11-1/3 inches	383	95	478	351	132	483
L. S. D. at .05	29.4	6.7	31.6	44.0	5.9	43.7

Table 3. Method of weed control x spacing on yields (Average of rates of fertilizer application)

Weed control&spacing		Irrigated U.S. 1	Irrigated No. 2	Irrigated Total	Not irrigated U.S. 1	Not irrigated No. 2	Not irrigated Total
Sinox General	34"	303	40	343	284	57	341
	17"	422	66	488	371	100	471
	11-1/3"	397	106	503	396	138	534
Wheel hoe	34"	359	34	393	321	51	372
	17"	349	66	415	347	81	428
	11-1/3"	368	84	452	306	127	433
L. S. D. at .05		29.4	9.5	44.6	62.2	N.S.	61.9

Data are not presented here to show it, however there were no significant differences in yields of U. S. 1, No. 2 or total between the various rates of fertilizer application with the exception of No. 2's of the unirrigated series. Likewise, the only significant difference in the interaction of method of weed control x fertilizer between the fertilizer rates was the No. 2 in the unirrigated series. The same was true in the interaction of spacing x rate of fertilizer application.

Experiment II

A similar experiment with the Green Mountain variety was conducted in Upstate New York on a sandy loam soil. Exceptions were that only two row spacings, 34 and 17 inches, were used rather than three. The rates of fertilizer application were 1600, 3100 and 4600 pounds 5-10-10 fertilizer to the acre. Potatoes were planted June 7 and Sinox General and diesel oil applied June 22 before the potato plants emerged.

Table 4. Method of weed control and yields (averages of rates of fertilizer applications and spacings)

Method of weed control	Irrigated U.S. 1	Irrigated No. 2	Irrigated Total	Not irrigated U.S. 1	Not irrigated No. 2	Not irrigated Total
Sinox General	273	58	331	204	56	260
Wheel hoe	241	59	300	222	52	274
L. S. D. at .05	31.0	N.S.	N.S.	N.S.	N.S.	N.S.

Table 5. Row spacing and yields. (averages of rates of fertilizer application and methods of weed control)

Spacing	Irrigated U.S. 1	Irrigated No. 2	Irrigated Total	Not irrigated U.S. 1	Not irrigated No. 2	Not irrigated Total
34 inches	249	40	289	219	36	255
17 inches	265	77	342	208	72	280
L. S. D. at .05	N.S.	6.5	31.2	N.S.	5.1	22.7

Table 6. Rate of fertilizer application and yields. (averages of method of weed control and spacing)

Rate of fertilizer per acre	Irrigated U.S. 1	Irrigated No. 2	Irrigated Total	Not irrigated U.S. 1	Not irrigated No. 2	Not irrigated Total
1600 lbs.	172	73	245	136	67	203
3100 "	273	54	327	231	49	280
4600 "	326	48	374	273	46	319
L. S. D. at .05	38.0	8.1	38.2	26.0	6.3	27.9

In the interaction of method of weed control x spacing and of method of weed control x rate of fertilizer application there were no significant differences. In the interaction of spacing x rate of fertilizer application significance occurred only in No. 2's in the irrigated series. In the interaction of method of weed control x spacing x rate of fertilizer application significance was evident only in the No. 2's in both irrigated and unirrigated series.

In a comparison of the rate of fertilizer application at the 34 inch spacing only, the following data were obtained:

Table 7. Rate of fertilizer application and yields. (average methods of weed control and spacing) 34 inch spacing only

Rate of fertilizer per acre	Irrigated U.S. 1	Irrigated No. 2	Irrigated Total	Not irrigated U.S. 1	Not irrigated No. 2	Not irrigated Total
1600 lbs.	187	45	232	154	43	197
3100 "	277	40	317	246	34	280
4600 "	324	34	358	276	32	308
L. S. D. at .05	43.0	7.7	45.5	29.2	4.2	30.3

Experiment III

Sebago potatoes planted May 26, 1949 in sandy loam soil were given the following treatments:

A. Method of weed control
(1) Sinox General 3 pints plus 6 gallons diesel oil per acre
(2) Wheel hoe

B. Spacing
(1) 34" x 12"
(2) 11-1/3" x 12"

C. Fertilizer application
(1) 1800 lbs. per acre
(2) 4000 lbs. per acre

All of the above combinations were used except (1) wheel hoe, 34" x 12" spacing, 4000 lbs. fertilizer and (2) wheel hoe, 34" x 12" spacing, 1800 lbs. fertilizer. Harvested plots were 22 ft. x 5 ft. 8 inches replicated four times. Sinox General and diesel oil were applied at the rate of 100 gallons to the acre on June 12 before emergence of the potatoes. The entire area was irrigated whenever it was deemed necessary. Control of broadleaved weeds and grasses throughout the season was nearly perfect in plots treated with Sinox General.

Table 8. Method of weed control and yields.

	11-1/3 inch spacing		
Weed control	U. S. 1	No. 2	Total
Sinox General	529	82	611
Wheel hoe	544	70	614
L. S. D. at .05	N.S.	N. S.	N.S.

Table 9.. Rate of fertilization and yields

Rate of fertilization	U. S. 1	No. 2	Total
1800 lbs. per acre	513	66	579
4000 " " "	518	71	589
L. S. D. at .05	N.S.	N.S.	N.S.

Table 10. Row spacing and yields

Spacing	U.S. 1	No. 2	Total
34 inches	473	52	525
11-1/3 inches	529	82	611
L. S. D. at .05	N.S.	13.1	51.0

Table 11. Method of weed control, rate of fertilization, spacing and yields.

Treatment	U. S. 1	No. 2	Total
Sinox General, 34", 1800 lbs.	488	44	532
" " , 34", 4000 "	459	60	519
" " , 11-1/3", 1800 lbs.	516	84	600
" " , 11-1/3", 4000 "	542	80	622
Wheel hoe, 11-1/3", 1800 lbs.	536	69	605
" " , 11-1/3", 4000 "	552	72	624
L. S. D. at .05	N.S.	N.S.	N.S.

SUMMARY

1. On Long Island no significant differences in yield of U. S. No. 1 or total yield occurred in the irrigated plots between control of weeds with Sinox General and with a wheel hoe. In unirrigated plots total yields and yield of No. 2 size were significantly higher in the Sinox General plots.

2. In both the irrigated and unirrigated series of plots on Long Island yields of U. S. 1, No. 2 and total yields were significantly higher at the 17 inch and 11-1/3 inch spacing than at the 34 inch spacing. This also was the case when Sinox General was used for controlling weeds. When the plots were wheel hoed, however, there were no significant differences in yields of U. S. No. 1 size between the three spacings.

3. In Upstate New York yields of U. S. No. 1 size were significantly higher in Sinox General treated and irrigated plots than in wheel hoed plots. There were significant increases of No. 2 and total yields at 17 inch spacing compared with 34 inch spacing in both irrigated and unirrigated areas.

4. In Upstate New York in both irrigated and unirrigated areas yields of U. S. No. 1 and total yields were significantly higher from applications of 4600 lbs. fertilizer to the acre than from 3100 lbs. and the latter was significantly higher than applications of 1600 lbs. to the acre. Yields of No. 2 were significantly higher at 1600 pounds fertilizer to the acre than at 3100 or 4600 pounds. Results were similar when the rates of fertilizer application were compared only at the 34 inch spacings.

5. At Ithaca there were no significant differences in yields between Sinox General and wheel hoed methods of controlling weeds nor between applications of 1800 and 4000 lbs. fertilizer to the acre. Spacing rows 11-1/3 inches apart resulted in significant yields of No. 2 and total yields over those spaced 34 inches apart.

WILD GARLIC AND ITS CONTROL BY 2,4-D

Glenn C. Klingman[1]

Wild garlic (Allium vineale L.) continues to be an important weed problem of the Eastern and Southeastern United States. Methods of control given in the literature from 1914 through 1947 are very similar. Anderson (1), Angrove (2), Cox (4), Hanson (5,6), (7), Moores (8), Pieper and Rickey (9), Scott (10), Sherwood (13), Talbot (14), Tinney (15), and Wild (16) gave methods of control that were principally cultural. The methods given all involve fall, winter or spring plowing to keep the winter growth of the garlic under control. Other cultural treatments were generally recommended during the winter months in addition to the plowing. Most recommendations included the production of an intertilled crop during the summer months. Treatments in all papers emphasized continued treatments varying from two to six years. Heavy grazing for several years, especially by sheep, was occasionally mentioned for pasture areas. Chemicals used were relatively ineffective and expensive.

Methods of reproduction of the garlic plant were well understood as early as 1914 by Cox (3). Based on those facts, there was little change in methods of control until 2,4-D was widely used for weed control. Early trials of 2,4-D on wild garlic were erratic and in general unsuccessful. Sell (11) first reported satisfactory control. The ester and amine forms of 2,4-D gave 80 to 93% control in one season. Sell, Dallavalle, and Crowder (12) reported that a 98% kill of wild garlic was obtained by a heavy application of 2,4-D when applied two years in succession. These workers reported that the amount of water used as a carrier was not important, providing uniform application was obtained. It was further reported that wetting or sticking agents did not increase the effectiveness of the 2,4-D on wild garlic.

Wild garlic control is made difficult by its four means of propagation. Its reproduction is by: soft-shelled below-ground bulbs which germinate in early fall; hard-shelled below-ground bulbs which germinate in late fall and spring, but may remain dormant for two seasons or more; by aerial bulblets which germinate in early fall; and from small black wrinkled seeds, particularly wrinkled seeds, particularly in Southern United States. A system of control therefore must effectively kill plants that germinate through the winter months for two years or more, without permitting reproduction.

[1]Associate Professor, North Carolina State College, on leave and at Rutgers University.

This study was conducted principally to determine the reaction of 2,4-D on wild garlic for use in working out better methods of control.

Materials and Methods

The study was conducted under field conditions in a North Carolina State College pasture that was heavily infested with wild garlic. The soil was principally a gravelly loam.

Twenty-nine different treatments were included which included three time schedules of treatment, three rates of treatment and three types of 2,4-D. In addition one treatment of mowing plus 2,4-D was studied. A check or no treatment was included for comparison. Four replications were included of each treatment except for the check and the combination of mowed plus 2,4-D plots. Eight replications were included of each of these two treatments. The plots were 7 feet wide and 12 feet long, with a 5 foot alley between replications.

The chemical was applied with a 7 foot boom equipped with eight Monarch No. 22 nozzles. The plots were sprayed twice to give a total application of 22 gallons of spray per acre per treatment.

Three time schedules of treatment were used. One group was treated three times (Nov. 26, Jan. 15, Mar. 15). The second group was treated twice (Dec. 20 and Mar. 15); and the third group was treated once on March 15.

An arbitrary amount of 2,4-D[1] was established as a "unit" based on the acid equivalent (2). One "unit" of the sodium salt was chosen as 1½ pounds; the triethanolamine salt as 1 pound; and the isopropyl ester as 1 pound. Three rates of treatment were included with the low rate as 1 unit, the medium rate as 2 units and the high rate as 4 units per acre. The chemical was divided equally according to the number of treatments. For example, the plots receiving the low rate of sodium salt received ½ pound treatments on November 26, January 15 and March 15. The plots treated on December 20 and again March 15 received 3/4 pound per treatment, while the plots treated only on March 15 received the total 1½ pounds on that date. The medium and high rates were increased accordingly. See Table 1.

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(1) The 2,4-D was supplied by the E. I. du Pont Semesan Division.

(2) All amounts of 2,4-D given in this paper are based on the "Acid equivalent" or pure 2,4-D acid.

Table 1. Estimated top injury(1) and average number of bulbs(2) remaining in wild garlic treated with 2,4-D, compared to mowing followed by a 2,4-D treatment(3).

	Total lbs. 2,4-D Applied per acre (Acid equiv.)	Top injury, Estimated 1.0-no injury;10 tops killed			No. of below ground bulbs per 2 sq.ft.plot		
		Date Chemical Applied			Date Chemical Applied		
		Nov. 26 Jan. 15 Mar. 15	Dec. 20 Mar. 15	Mar. 15	Nov. 26 Jan. 15 Mar. 15	Dec. 20 Mar. 15	Mar. 15
Sodium Salt	1½	1.75	2.00	1.50	45.00	46.38	57.75
Triethanolamine	1	3.75	3.50	2.50	39.38	43.25	56.75
Isopropyl Ester	1	5.25	4.25	4.75	42.50	46.00	66.25
Sodium Salt	3	3.25	2.25	2.75	44.00	37.88	55.62
Triethanolamine	2	7.50	7.75	4.25	35.75	38.88	30.12
Isopropyl Ester	2	8.50	8.50	5.75	32.00	42.21	29.25
Sodium Salt	6	5.75	5.50	5.50	36.25	37.38	41.50
Triethanolamine	4	8.25	9.25	7.50	23.88	29.75	35.00
Isopropyl Ester	4	10.00	9.50	10.00	24.88	26.75	35.75
Mowed, 2,4-D(3)		7.62	7.62	7.62	31.06	31.06	31.06
Check(4)		1.00	1.00	1.00	75.37	75.37	75.37
L.S.D. between	.05	1.4289	1.4289	1.4289	21.94	21.94	21.94
Chemical Treatments	.01	1.8887	1.8887	1.8887	29.06	29.06	29.06
L.S.D. of check or mowed(3) vs. any other treatment	.05	1.2359	1.2359	1.2359	18.90	18.90	18.90
	.01	1.6371	1.6371	1.6371	25.03	25.03	25.03
		C.V. 18.7%			C.V. 52.9%		

(1) Estimated on May 5, 1949. Each number the average of four plots.
(2) Bulbs dug between May 25 and June 15, 1949. Each number the average of 8 plots.
(3) Mowed Dec. 21, Jan. 17, and Feb. 20. Sprayed March 15 with 1 lb. Isopropyl ester per acre (acid equiv.). Top injury was determined from 8 plots, number of bulbs from 16 plots.
(4) Estimation of top injury was from 8 plots; No. of bulbs counted was from 16 plots.

The "mowed plus 2,4-D plots" were cut at a 2 inch height with a home type lawn mower on December 21, January 17 and February 20. This was followed on March 15 with a treatment of 1 pound per acre of the isopropyl ester of 2,4-D.

Plots were rated according to top injury on May 5. A rating of 1.0 indicated no injury and 10.0 complete top kill.

In each treated area two small plots 2 feet long and 1 foot wide were dug and the underground hard-shelled bulbs counted. The counts were made between May 25 and June 15.

Observations as to the date of bulb germination and date of formation of new bulbs were also made.

Experimental Results

In Table 1 are reported the average ratings as to top injury and also the number of below ground bulbs for the various treatments.

Top injury was significant at the 1.0% level for all treatments as compared to growth of the check plots, except for all low rates of the sodium salt, the low rate of the triethanolamine salt applied on March 15 and for the medium rate of sodium salt applied on December 20 and March 15. The "mowed plus 2,4-D treatment" compared favorably in regard to top injury with all treatments except the higher rates of treatment with the isopropyl ester and the triethanolamine salt. The coefficient of variability between the top injury ratings was 18.7%, indicating that the tops of the plants hit by the various sprays responded similarly in the different replications.

A discussion of the significant differences between each of the chemical treatments would be voluminous and will not be attempted here. The comparisons can be easily made from Table 1. In general, the multiple treatments were slightly more effective than one single treatment, with an increase in top injury with all increased rates of treatment.

The number of below-ground bulbs was reduced at the 1.0% level of significance by all treatments when compared to the check plots, except for the low rate of all three types of 2,4-D applied on March 15, and for the medium rate of the sodium salt applied on March 15.

The mowed plus 2,4-D application gave nearly as great a reduction in bulb formation as was evidenced in the best of the other treatments. The difference was not significant at the 5.0% level.

The significant differences between the number of bulbs found within the various treatments can be easily determined from Table 1. Similar to the top injury, the reduction in number of bulbs tended to be greater with the multiple date treatments as compared to the single March 15 treatment, and also with each increase in the amount of the chemical used.

The coefficient of variability of 52.9% in the number of bulbs indicated that the distribution of garlic bulbs was far more variable than would have been estimated from the original population of plants. It also indicated that there may be considerable variability in dormancy of the hard-shelled bulbs.

A summary of the effect on top injury of the three chemicals applied on the various dates without regard to rate is shown in Table 2. The average of the December - March dates of treatment was significantly higher at the 5.0% level than the March 1 treatment, with the November - January - March treatment significant at the 1.0% level. There was no statistical difference between the average of the November - January - March treatment and the average of the December - March treatment. The average figures show that the isopropyl ester was more effective than the triethanolamine, and that the sodium salt was the least effective in killing the tops. Variations between individual treatments tend to be the same as their averages as shown in Table 2.

Table 2. Top kill(1) as influenced by date of application of various types of 2,4-D; compared to mowing followed by a 2,4-D treatment and check plots. (1-no injury; 10-tops killed.)

	Date Chemical Applied			
	Nov. 28 Jan. 15 March 15	Dec. 20 March 15	March 15	Average
Sodium Salt(2)	3.58	3.25	3.25	3.36
Triethanolamine(2)	6.50	6.83	4.75	6.03
Isopropyl Ester(2)	7.92	7.42	6.83	7.39
Average	6.00	5.83	4.94	
Mowed, 2,4-D(3)	7.62	7.62	7.62	
Check(4)	1.00	1.00	1.00	

L.S.D. between chemical treatments	(.05)	.4753
	(.01)	.6296
L.S.D. between check or mowed(3) vs. average of any other treatment	(.05)	.7880
	(.01)	1.044

(1) Estimation made on May 5, 1949.
(2) Each number the average of 12 plots.
(3) Mowed Dec. 21, Jan. 17 and Feb. 20. Sprayed March 15 with 1 lb. acid equiv. per acre of Isopropyl ester of 2,4-D. Each number the average of 8 plots.
(4) Check - (No treatment). Each number the average of 8 plots.

A summary of the effect on top injury of the three chemicals without regard to the date of treatment is shown in Table 3. The top kill was increased significantly (.01) with each increase in rate of chemical treatment as shown by the averages 3.25, 5.61 and 7.92. Individual treatments gave the same general trend.

Table 3. Top kill[1] as influenced by rate of application of various types of 2,4-D; compared to mowing followed by a 2,4-D treatment and check plots. (1-No injury; 10-tops killed.)

	Rate of 2,4-D Treatment		
	Low	Medium	High
Sodium Salt[2]	1.75	2.75	5.58
Triethanolamine[2]	3.25	6.50	8.33
Isopropyl Ester[2]	4.75	7.58	9.83
Average	3.25	5.61	7.92
Mowed, 2,4-D[3]	7.62	7.62	7.62
Check[4]	1.00	1.00	1.00
L.S.D. between chemical treatments (.05)			.4753
(.01)			.6296
L.S.D. between check or mowed[3] vs. average of any other treatment (.05)			.7880
(.01)			1.044

(1) Estimation made on May 5, 1949.
(2) Each number the average of 12 plots.
(3) Mowed Dec. 21, Jan. 17 and Feb. 20. Sprayed March 15 with 1 lb. acid equiv. per acre of Isopropyl ester of 2,4-D. Each number the average of 8 plots.
(4) Check (no treatment). Each number the average of 8 plots.

The number of below ground bulbs as influenced by date of application without regard to rate of application is given in Table 4. Definite trends can be seen from the average figures, however, due to the large coefficient of variability, as previously discussed, large numbers have resulted for the various L.S.D. values. Hence no statistical significance is shown between the averages of chemical treatment. All treatments did result in a significant reduction in the number of the bulbs as compared to the check.

The number of below ground bulbs as influenced by rate of application without regard to date is given in Table 5. The

Table 4. Number of below ground bulbs[1] as influenced by date of application of various types of 2,4-D; compared to mowing followed by a 2,4-D treatment, and check plots.

	Date Chemical Applied			
	Nov. 26 Jan. 15 March 15	Dec. 20 March 15	March 15	Average
	Bulbs	Bulbs	Bulbs	
Sodium Salt[2]	41.75	40.54	51.62	42.64
Triethanolamine[2]	33.00	37.29	40.62	36.97
Isopropyl Ester[2]	32.92	38.29	43.75	28.32
Average	35.89	38.71	45.33	
Mowed, 2,4-D[3]	31.06	31.06	31.06	31.06
Check[4]	75.37	75.37	75.37	75.37

L.S.D. between chemical treatments	(.05)	7.31
	(.01)	9.69
L.S.D. between check or mowed[3] vs. average of any other treatment	(.05)	12.12
	(.01)	16.06

(1) Below ground bulbs dug and counted between May 25 and June 15.
(2) Each number the average of 24 plots.
(3) Mowed Dec. 21, Jan. 17, and Feb. 20. Sprayed March 15 with 1 lb. acid equiv. per acre of Isopropyl ester of 2,4-D. Each number the average of 16 plots.
(4) Check - (no treatment). Each number the average of 16 plots.

average number of below ground bulbs is significantly (.01) less for the high rate of treatment compared to the low rate. There was a slight increase in the number of bulbs at the medium rate of treatment as compared to the high rate, however, the difference was not significant. The same trends were apparent between individual chemical treatments, as was shown by their averages.

Observations showed that new bulbs were being initiated in mid-January in plants that had started growth in the early fall. Most of the hard shelled bulbs germinated in November, December and January with germination continuing into March.

Discussion

Some treatments permitted little top growth during the normal growing season of the garlic. At the end of the growing season no garlic was to be seen on these plots above ground. The fact that in these plots there was still a reasonably large number of

Table 5. Number of below ground bulbs(1) as influenced by rate of application of various types of 2,4-D; compared to mowing followed by a 2,4-D treatment, and check plots.

	Rate of 2,4-D treatment		
	Low Bulbs	Medium Bulbs	High Bulbs
Sodium Salt(2)	49.71	45.83	38.38
Triethanolamine(2)	46.45	34.91	29.54
Isopropyl Ester(2)	51.58	34.46	28.92
Average	49.25	28.40	32.28
Mowed, 2,4-D(3)	31.06	31.06	31.06
Check(4)	75.37	75.37	75.37
L.S.D. between chemical treatments	(.05)	7.31	
	(.01)	9.69	
L.S.D. between check or mowed(3) vs. average of any other treatment	(.05)	12.12	
	(.01)	16.06	

(1) Below ground bulbs dug and counted between May 25 and June 15.
(2) Each number the average of 24 plots.
(3) Mowed Dec. 21, Jan. 17, and Feb. 20. Sprayed March 15 with 1 lb. acid equiv. of Isopropyl ester of 2,4-D. Each number the average of 16 plots.
(4) Check - (no treatment). Each number the average of 16 plots.

bulbs, shows conclusively that the bulbs remain dormant for one year or longer. This further explains the reason that in both chemical and cultural recommendations, treatments are recommended through two or more winter seasons. In another study (unpublished) made by the author during 1947, 1948 and 1949 indications were obtained, that from 70 to 90 percent of the hard-shelled bulbs germinate the first year, and 95 to 98% of the total number germinate within the first two years. Various soil factors are believed important in regulating dormancy of the hard-shelled bulbs.

As reported by (11), the top injury is not necessarily a true indication of effectiveness in reducing the number of bulbs. For example, the low rate of the sodium salt did not give significant top injury, while the number of below ground bulbs was significantly reduced.

The reduction in the number of bulbs by the three mowings followed by 1 pound of the ester form of 2,4-D has considerable importance when applied to Ladino Clover pastures infested with wild garlic. It is believed that the amine form of 2,4-D would be nearly as effective.

Hence, repeated grazing or mowing followed by the application of 2,4-D in early March is suggested. If the practice is followed for two years, the garlic population should be heavily reduced. Only well established Ladino clover will withstand 1 pound of 2,4-D per acre. Even this amount will cause considerable injury for three to four weeks.

As indicated from the data, 2,4-D alone applied over a period of several years can be expected to give good control of wild garlic. The amounts required, however, will kill Ladino clover.

Summary

Twenty-nine different treatments of wild garlic were made during the fall, winter and spring of 1948-49. The treatments involved the use of three types of 2,4-D, at three different rates, with three different time schedules of application. In addition a treatment of repeated mowings through the winter followed by an application of 2,4-D was included. All were compared to the check or no treatment plots.

The Isopropyl ester of 2,4-D was the most effective in killing the tops and the sodium salt the least. The Isopropyl ester and triethanolamine type of 2,4-D had similar effects in reducing the number of bulbs formed. The sodium salt was somewhat less effective.

Reasonably high rates of chemical treatment were needed where chemical control was used alone for garlic control.

A combination of mowing during the winter followed by an application in early March of one pound of the ester or amine form of 2,4-D appears promising for pastures containing Ladino Clover. Heavy grazing to keep the top growth of the garlic down is expected to be comparable to the mowing.

More than one year of treatment will be needed for complete control of wild garlic due to the dormancy of below ground bulbs.

Treatments that kill, or prevent food storage in the below-ground bulbs followed by chemical treatment in the spring appears to be more effective than a single spring treatment on well developed plants.

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ONE YEAR'S RESULTS ON THE EFFECT OF 2,4-D ON LEGUMES OF HAY FIELDS AND PASTURES[1]

L. G. Butler, Dale E. Wolf and Gilbert H. Ahlgren[2]

The possibility of controlling weeds in hayfields and pastures using 2,4-dichlorophenoxyacetic acid (hereinafter referred to as 2,4-D) was investigated at the New Jersey Agricultural Experiment Station in 1949.

Pure stands of Northwestern alfalfa, Cumberland red clover and super alsike clover were seeded September 3, 1948. On April 27 and May 7, 1949 each of the three species was treated with 1/8, 1/4 and 1.0 lb./acre rate of the butyl ester of 2,4-D. At both dates the plants were still in the vegetative phase of growth, there were no signs of flower buds. On the first date, the average heights were: alfalfa 12 inches; red clover 10 inches and alsike 9 inches. On the second date the average heights were: alfalfa 16 inches; red clover 14 inches and alsike 13 inches.

A pasture with an established stand of ladino clover and orchard grass was treated with 1/8, 1/4, 1/2 and 1.0 lb./acre rates on June 3, 1949 of the butyl ester of 2,4-D.

Spring oats, alfalfa, red clover and ladino were seeded together April 8, 1949. These plots were treated with 1/16, 1/8, and 1/2 lb./acre rates of the butyl ester of 2,4-D on May 14, May 24, June 2 and June 18.

The results were not clear cut and on the basis of one summer's work, definite conclusions cannot be made. The month of June was without rainfall, a highly abnormal situation for New Jersey. However, certain observations are of interest.

The second date of treatment on alfalfa, applied ten days after the first date, did not result in as severe damage as did the first date (Table 1). The alfalfa, at the second date, was an average of four inches taller than the first date, there was no sign of flower bud formation.

The alsike clover makes such a poor recovery especially after cutting, that no definite conclusions could be made.

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[1]Acknowledgment is made to the Sherwin-Williams Company for their support of this project.

[2]Research Fellow, Farm Crops Department; Agent, U.S.D.A. and Assoc-Research Specialist, New Jersey Agricultural Experiment Station; and Professor of Farm Crops, Farm Crops Department, Rutgers Univ.

Table 1. Percentage composition of pure stands of alfalfa, red clover and alsike clover after four rates and two dates of treatment with the butyl ester of 2,4-D.

Rate	1st Date				2nd Date			
	ALFALFA							
0.0 lb./A	Alfalfa	96	Weeds	4	Alfalfa	95	Weeds	5
1/8 lb./A	Alfalfa	63	Weeds	37	Alfalfa	93	Weeds	7
1/4 lb./A	Alfalfa	16	Weeds	84	Alfalfa	78	Weeds	22
1.0 lb./A	Alfalfa	9	Weeds	91	Alfalfa	50	Weeds	50
	RED CLOVER							
0.0 lb./A	Red C.	94	Weeds	6	Red C.	94	Weeds	6
1/8 lb./A	Red C.	74	Weeds	26	Red C.	82	Weeds	18
1/4 lb./A	Red. C.	57	Weeds	43	Red C.	39	Weeds	61
1.0 lb./A	Red C.	40	Weeds	60	Red C.	18	Weeds	82
	ALSIKE CLOVER							
0.0 lb./A	Alsike	44	Weeds	56	Alsike	84	Weeds	16
1/8 lb./A	Alsike	41	Weeds	59	Alsike	30	Weeds	70
1/4 lb./A	Alsike	17	Weeds	83	Alsike	11	Weeds	89
1.0 lb./A	Alsike	10	Weeds	90	Alsike	7	Weeds	93

The established stand of ladino clover-orchard grass shows a regular decrease of ladino clover as the rate of 2,4-D increases (Table 2). The area was heavily grazed in the fall of 1948, to the extent that the clover was weakened enough to show

Table 2. Percentage composition of an established ladino clover-orchard grass pasture after five rates and one date of treatment with the butyl ester of 2,4-D.

Rate	Ladino Clover	Orchard Grass	Weeds
0.0 lb./A	36.0%	50.0%	14.0%
1/8 lb./A	31.0	59.0	11.0
1/4 lb./A	26.0	64.0	10.0
1/2 lb./A	21.0	72.0	7.0
1.0 lb./A	15.0	80.0	5.0

delayed spring growth. Also this pasture was used in a rotational grazing program, having been grazed both before and after the treatment. Other workers have indicated that established ladino suffers no material injury when treated with rates up to 1 lb./Acre.

In the spring oats-legume spring seeding, the first and second dates of treatment produced the greatest decrease in legume stand since they are less tolerant at this time and the oat foliage could not offer sufficient protection (Table 3). The third date,

Table 3. Percentage composition of a spring oats-legume spring seeding after four rates and four dates of treatment with the butyl ester of 2,4-D.

Rate	Date	Alfalfa	Red Clover	Ladino Clover	Weeds
0.0 lb./A	1	68%	16%	10%	6%
	2	72	13	10	6
	3	64	16	12	8
	4	55	16	22	7
1/16 lb./A	1	3%	2%	15%	80%
	2	5	6	19	70
	3	13	6	28	52
	4	42	13	12	33
1/8 lb./A	1	6%	6%	17%	71%
	2	-	3	21	76
	3	4	2	27	67
	4	36	6	21	37
1/2 lb./A	1	-	-	4%	96%
	2	-	-	3	97
	3	-	2%	16	82
	4	38%	1	17	44

applied nine days after the second date, was less damaging than either the first or second dates. The ladino clover was better developed and the oats offered more protection. The fourthdate was applied sixteen days after the third date, there having been no rain since May 28. The legumes were not growing, the leaves were rolled somewhat, the plants were dormant or "hardened off" and the oats were in head. This date of treatment suffered the least injury.

Conclusions

The butyl ester of 2,4-D in concentrations exceeding 1/4 lb./A eliminated about 75% of the alfalfa, about 50% of the red clover and about 75% of the alsike clover when the plants were less than one year old. The effect upon the alsike was highly variable.

Ladino clover in an orchard grass-ladino mixture was reduced about 50% by the 1.0 lb./A rate when closely grazed before and after treatment.

In a spring oats or a winter wheat-legume mixture, the companion crop should be 20-22 inches high and rate cannot exceed 1/4 lb./A of the butyl ester without severely damaging the legumes.

Preliminary Report on Pre-emergence Weed Control for Field Beans

by: A. J. Tafuro[1] and J. D. VanGeluwe[2]

The weed problem with field beans starts at seeding time, causing a heavy expense item in comparison to the crop value. The susceptibility of the bean plant to 2,4-D (2,4-dichlorophenoxy-acetic acid) has brought about the use of other herbicides for pre-emergence weed control. This preliminary report deals with a pre-emergence application of different herbicides to red kidney field beans.

Methods and Materials

The herbicides used were triethanolamine salt of 2,4-D at 1/2 and 3/4 pounds acid equivalent per acre, aromatic oil PD-975A* at 30 gallons per acre; HAN-132** aromatic oil at 30 gallons per acre and G.L.F. Experimental Herbicide #1*** at 3 and 5 gallons per acre. G.L.F. Herbicide #1 is an aromatic oil reinforced with pentachlorophenol plus a wetting agent. The individual plots included six rows of beans forty feet long replicated twice and untreated, non-cultivated and normal cultivated checks for each replicate was included. Materials were applied with a low pressure low volume spray rig attached to a jeep at 30 gallons of spray volume per acre. The experimental plots were part of a large field of beans on the farm of Everett Blazey at Victor, New York. The crop was planted on June 17th, 1949 and materials were applied on June 21st or about 24 hours before bean plants broke through the ground. Treated plots received only one cultivation on July 12th after the second weed counts were made, whereas the normal cultivation plots received one weeding by a weeder before come-up and three cultivations after emergence. Weed counts were taken on July 6th, and 10th and yield records on October 21st.

Weed species present were Wild mustard (Brassica arvensis), Common ragweed (Ambrosia Artemisifolia) and Pigweed (Amaranthus retroflexus).

*Socony Vacuum Oil Co.
**Esso Standard Oil Co.
***G.L.F.Soil Building Serv.Div.Coop.G.L.F. Exchange,Inc.

1 and 2 G.L.F.Soil Building Service, a division of Cooperative G.L.F. Exchange, Inc.

Experimental Results

Weed counts were taken 14 and 18 days after materials were applied. Table I below indicates weed population 14 days after application from both replicates.

TABLE I

Material	Concen-tration	No. weeds in 6 square feet		Total weeds in Reps. 1 & 2	No. grasses in 6 square feet		Total grasses in Reps. 1 & 2
		Repl. 1	Repl.2		Repl. 1	Repl.2	
GLF Exp. Herb #1	3 gal/A.	265	31	296	1	3	4
GLF Exp. Herb #1	5 gal/A.	153	54	207	3	1	4
Esso HAN	30/A.	236	45	292	0	7	7
Socony Oil	30/A.	71	36	107	1	5	6
2,4-D	½ lb/A.	18	4	22	0	4	4
2,4-D	3/4 lb/A.	7	1	8	3	3	6
Check		208	119	327	2	0	2

Excellent weed control was observed on the plots receiving the triethanolamine salt of 2,4-D at rates of ½ and 3/4 pounds acid equivalent, but severe injury to the trifoliate leaves was observed. Two weeks after spraying Socony PD975A aromatic oil gave good initial weed control. G.L.F. Experimental Herbicide #1 at both concentrations and Esso HAN-132 aromatic oil gave partial control of weeds and residual effect seemed to be depleted less than two weeks after spray was applied. At the time of this count G.L.F. Experimental Herbicide #1 and Esso HAN-132 seemed to have no residual effect on control of weeds since there were more weeds and larger weeds in these plots in comparison with the 2,4-D and Socony oil plots. Injury to bean plants was observed in the 2,4-D plots only.

Table II below indicates weed population 18 days after application from both replicates.

TABLE II

Material	Concentration	No. weeds in 6 square feet		Total weeds in Reps. 1&2	No. grasses in 6 square feet		Total grasses in Reps. 1&2
		Repl. 1	Repl. 2		Repl. 1	Repl. 2	
GLF Exp. Herb. #1	3 gal/A.	277	57	334	4	2	6
GLF Exp. Herb. #1	5 gal/A.	269	84	353	1	1	2
Esso HAN	30/A.	282	59	341	1	2	3
Socony Oil	30/A.	194	71	265	1	5	6
2,4-D	½ lb/A.	7	3	10	4	0	4
2,4-D	3/4 lb/A.	2	0	2	3	1	4
Check		243	189	432	0	7	7

G.L.F. Experimental Herbicide #1 and Esso HAN 132 aromatic oil at 18 days after spray had weeds as tall as those in the checks whereas Socony PD-975A oil plots had an increase count of weeds but all weeds were in the early colytedon stage. Residual effect on Socony oil seemed to deplete at this stage. 2,4-D plots were still very free of weeds and trifoliate leaves showed epinasty but no other part of the bean plant developed any abnormalities. Six weeks after spray was applied practically all epinasty to bean plants from the 2,4-D sprays had disappeared.

Yields of dry beans were taken from all treated plots in both replicates, untreated checks from both replicates and two checks from the portion of the field that had normal cultivation. Two rows, each 25 feet long, were taken from each plot for yield records.

Table III indicates yields from each replicate taken on October 21st.

TABLE III

Material	Concentration	Yields taken from 2 rows, 25' long		Total yield from both replicates	Yield increase in lbs. over cult. check	% increase over cultivated check
		Repl. 1	Repl. 2			
GLF Exp. Herb. #1	3	6.9 lbs.	7.0 lbs.	13.9 lbs	.6	+ 4.5
GLF Exp. Herb. #1	5	7.7 lbs.	6.9 lbs	14.6 lbs	+ 1.3	+ 9.8
Esso HAN	30	7.3 lbs	6.6 lbs	13.9 lbs	+ .6	+ 4.5
Socony	30	5.5 lbs.	7.6 lbs	13.1 lbs	-.2	-1.5
2,4-D	1/2 lb.	4.9 lbs.	6.6 lbs.	11.5 lbs	-1.8	-13.5
2,4-D	3/4 lb.	6.2 lbs	5.9 lbs.	12.1 lbs	-1.2	-9.0
Untreated Check		7.0 lbs.	4.8 lbs	11.8 lbs		
Cultiv. Check		6.4 lbs	6.9 lbs.	13.3 lbs.		

Little or no significant differences were observed in treatments except in the 2,4-D plot where it seemed evident that injury to the trifoliate leaves caused a decrease in yield.

Summary

2,4-D gave better weed control than the other materials but developed epinasty to trifoliate leaves of the bean plant. Bean plants did not show any symptons of epinasty six weeks after spray.

Socony Vacuum PD-975A aromatic oil gave good weed control for three weeks after spray and eliminated one weeding by a weeder and two cultivations.

Socony Vacuum PD-975A seemed superior over G.L.F. Experimental Herbicide #1 and Esso HAN-132 aromatic oil in controlling weeds.

G.L.F. Experimental Herbicide #1 and Esso HAN-132 aromatic oil gave only partial control of weeds for fourteen days.

Although weed counts between plots indicated superior weed control from some materials there was little or no significant differences in yield.

It is evident that the injury to the trifoliate leaves caused by the use of 2,4-D, gave a decrease in yield.

Pre-emergence Weed Control in Corn with Cyanamid[1]

F. B. Muller and T. E. Odland[2]

Cyanamid has been used successfully in controlling weeds in tobacco seed beds (1) in lawns previous to seeding (2,3,5). Recently it has been used with promising results for weed control in field corn (4,6). More information on the best methods of using cyanamid for this purpose seemed highly desirable. Many factors such as soil type, time and method of application, soil moisture and rate of application are all important considerations.

Experiments were conducted at the Rhode Island Experiment Station over a 3-year period, 1947-49, with cyanamid for weed control in field corn. Variables included rate and time of application, cyanamid form, soil preparation and method of application. The results will be reported in this paper.

Materials and Methods

The experiments were located at the Agronomy experimental plots at Kingston. The soil is classified as Bridgehampton very fine sandy loam. It is in a high state of fertility. The plots were 15 x 19 feet in 1947 and 1948. In 1949 they were 15 x 27 feet. Each treatment consisted of 4 replicates in 1947 and 1949 and 3 replicates in 1948. The fertilizer applied consisted of 1,000 pounds per acre of a 4-12-8 grade. In 1947, Mass 62 hybrid corn was grown and in 1948, and 1949 Ohio K-24. The following data summarize the cultural operations for the 3 years:

	Corn Planted	Cyanamid Applied	Weed Counts	Cultivated	Harvested
1947	May 28	May 29	June 25	July 15	Oct. 20
1948	May 20	May 23	July 7	July 12	Oct. 7
1949	May 16	May 18 & 24	June 21	July 7	Oct. 19

In 1948 the land was prepared for planting at 2 different times: One week before planting and on the same day as planting. Also, half of the plots were rolled after planting and prior to the cyanamid application. In 1949, the cyanamid was applied immediately after planting and one week later. Granular cyanamid was used throughout except in 1947 when pulverized cyanamid was included. Broadcast and band applications were also compared in 1949. The band treatment consisted of broadcasting the cyanamid directly over the planted rows in bands 14 to 16 inches wide.

Results

The data on weed control in 1947 are presented in table 1.

[1]Contribution No. 754 of the Rhode Island Agr. Exp. Station, Kingston, R.I.

[2]Graduate Assistant and Head, Department of Agronomy, respectively.

Table 1. Weeds in corn in cyanamid test, 1947.

Cyanamid Form	Lbs./A	Surface or raked in	Weed* rating	% grasses
Granular	150	surface	3	90
"	300	"	3	95
"	300	raked	2	87
Pulverized	300	surface	3	92
"	300	raked	4	94
Granular	600	surface	2	95
"	600	raked	4	67
Pulverized	600	surface	3	96
"	600	raked	3	98
Check	---	---	5	88

*0 = no weeds; 5 = 100% of surface covered - chiefly crabgrass.

Both the granular and pulverized forms of cyanamid were effective to some extent. They were of about the same value. Raking the cyanamid into the soil after application did not add to the effectiveness of the treatments. There was no advantage in applying more than 300 pounds per acre for weed control. All plots were cultivated on July 15.

The yields obtained in 1947 are shown in table 2.

Table 2. Yields in bushels of shelled corn per acre on cyanamid plots in 1947 at Kingston, R. I.

Cyanamid Form	Lbs./A	Application	Bushels
Granular	150	surface	67.5
"	300	surface	74.2
"	300	raked	65.9
Pulverized	300	surface	77.0
"	300	raked	69.9
Granular	600	surface	76.2
"	600	raked	82.6
Pulverized	600	surface	79.7
"	600	raked	78.5
Check	---	---	46.3
LSD .05			12.3

There was a gradual increase in yields with increasing amounts of cyanamid used. The two forms of cyanamid were of equal value. Raking the cyanamid into the soil after application did not increase yields over the non-raked plots. The increase in yield obtained with the cyanamid applications indicates that the crop benefited greatly from the additional nitrogen applied. Regardless of the effect on weed control, the cyanamid paid good dividends on the investment from the increased yields secured.

Weed counts for 1948 are shown in table 3.

Table 3. Weeds in corn in cyanamid test, 1948*.

Cyanamid	Land prepared one week before planting		Land prepared just prior to planting	
Lbs./A	Weed rating**	% grasses	Weed rating**	% grasses
200	4	52	4	57
400	2	50	3	67
600	1	74	2	73
800	1	75	1	75
Check	5	50	4	50

* Average of rolled and non-rolled plots.
** 0 = no weeds; 5 = 100% of surface covered.

There seemed to be a slight advantage in preparing the land one week before planting and treating in controlling weeds. No difference in weed control was noted between rolling and not rolling the plots before applying the cyanamid. Weed control increased with increasing amounts of cyanamid applied, up to the 800-pound rate. However, considerable injury resulted from the 800-pound application, and even a little with 600 pounds. The percentage of grasses increased as more cyanamid was applied, showing that broadleaf weeds were more susceptible to the chemical than the grasses. Weed control with 200 pounds of cyanamid was not satisfactory.

The yields on the rolled and non-rolled plots were so very near the same for plots otherwise treated alike that they are not reported separately. The figures shown are the average for both treatments.

The yields obtained in 1948 are shown in table 4.

Table 4. Yields in bushels of shelled corn per acre on cyanamid plots in 1948 at Kingston, R. I.*

Treatment	Land prepared one week before planting		Land prepared just prior to planting		Av.
	Not Cult.	1 Cult.	Not Cult.	1 Cult.	
200 lbs.	21.2	35.5	19.7	43.3	29.9
400 lbs.	30.7	31.0	27.2	43.5	33.1
600 lbs.	28.5	35.1	48.3	61.1	43.2
800 lbs.	26.7	26.0	47.1	56.9	39.2
Check	6.1	28.3	14.2	41.3	22.5

*Yields are average of both rolled and non-rolled plots.

The 1948 season was very unfavorable for corn generally and none of the yields are high. The corn on the plots receiving neither cyanamid nor cultivation was practically a total failure. Increases in yield were obtained with increasing amount of cyanamid up to 600 pounds per acre. Increasing this amount to 800 pounds resulted in reduced yields. At least one cultivation was highly necessary. Preparing the land just previous to planting was a better practice than preparing it a week early. Rolling the plots proved to be extra labor without additional returns.

Weed counts in 1949, table 5, show a decided advantage for the cyanamid applied a week after planting.

Table 5. Weeds in corn in cyanamid test, 1949.

Cyanamid Lbs./A	Broadcast or band appl.	Applied at planting time		Applied 6 days after planting	
		Weed rating*	% grasses	Weed rating*	% grasses
200	Broadcast	5	85	2	85
200	Band	5	60	3	72
400	Broadcast	5	85	1	85
400	Band	4	60	1	60
600	Broadcast	4	80	1	80
600	Band	3	60	1	80
Check	--	(5)	(60)		

*0 = no weeds; 5 = 100% surface covered - chiefly crabgrass.

The 400-pound band application and both the 600-pound applications were practically weed free a month after treating. Some injury resulted from band applications, however, and there was no weed control between the bands. Since the bands were 14 inches to 16 inches wide, rates equivalent to approximately 1,000 pounds and 1,500 pounds per acre were applied in the bands for the 400 and 600-pound treatments. The 400 and 600-pound band applications were still relatively free from weeds when the plots were cultivated July 7.

The yields for 1949 are reported in table 6.

Table 6. Yields in bushels of shelled corn per acre on cyanamid plots in 1949 at Kingston, R. I.

Method of Application	Lbs./A	Applied just after planting	Applied 6 days after planting
Broadcast	200	10.4	53.3
Band	200	15.2	47.1
Broadcast	400	20.0	71.9
Band	400	23.5	58.9
Broadcast	600	20.7	82.2
Band	600	20.8	51.7
Average		18.4	60.8
Check	none	(14.1)	
LSD .05		N. S.	20.3

Applying the cyanamid one week after planting more than tripled the yields over the treatments applied just after planting. There was little difference in yields between band and broadcast applications when applied immediately after planting. Yields increased up to a maximum of 23.5 bushels for the 400-pound band application. When the cyanamid was applied 6 days after planting, yields increased from the check to a maximum of 82 bushels with each increase in broadcast applications. Band applications were consistently lower than the broadcast applications, probably due to poorer weed control between bands and to injury from excess cyanamid.

Discussion

The factor having the greatest influence on the action of cyanamid during the past three years was the amount of the rainfall following the cyanamid applications, and the soil moisture conditions preceding and following the treatments.

Table 7 summarizes the monthly rainfall for the 1947, 1948 and 1949 growing seasons (a), with a breakdown of the rainfall for one month following application of the cyanamid (b).

In 1947, rainfall was adequate throughout the growing season and was evenly distributed, so that soil moisture was ample.

Table 7. (a) Monthly rainfall in inches for the 1947, 1948 and 1949 growing seasons at Kingston, R. I.

	Apr.	May	June	July	Aug.	Sept.	Total
Normal	3.93	3.07	3.66	2.42	4.08	3.80	20.96
1947	5.26	4.42	3.31	4.79	1.62	2.35	21.75
1948	4.20	8.61	2.37	1.87	0.79	0.96	18.80
1949	4.57	2.63	0.04	1.89	2.51	4.02	15.66

(b) daily precipitation for one month following cyanamid applications

1947		1948		1949	
May 30	.11	May 26	.22	May 20	.57
June 3	.12	" 30	1.56	" 22	.48
" 8	.87	" 31	1.42	" 23	.25
" 9	.09	June 5	.23	" 25	.35
" 14	.06	" 8	.25	" 27	.10
" 15	.08	" 10	.10	" 28	.02
" 18	.09	" 12	.18	June 26	.04
" 19	.05	" 13	.55		
" 24	1.72	" 18	.20		
" 25	.27	" 19	.42		
		" 23	.18		
Total	3.46		5.31		1.81

The rainfall for the month following application of the cyanamid in 1948 was nearly double the normal amount. In 1947 and 1948 there was ample moisture for the solution and decomposition of the cyanamid. In 1948, however, so much rain fell that considerable amounts of nitrogen from the fertilizer must have been leached from the soil. Under those conditions of rapid decomposition and leaching, weed control was not too successful, and the weeds competed seriously with the crop for nutrients and moisture in the drought which followed. The one cultivation in July served a two-fold purpose: Weeds were controlled to some extent, and more important, the hard crust formed by the heavy spring rains was broken. This permitted aeration, better root growth, and nitrification of the residual cyanamid.

Results obtained in 1949 seem to be directly related to the amount of rainfall following the applications of the cyanamid. In the 10-day period following the May 18 application, 1.77 inches of rain fell. Weed control was good on those plots for about three weeks, but by the time the weed count was taken on June 21, the effect had largely worn off. The plots were greener and healthier looking than the plots treated May 24.

Only .47 inch of rain occurred after the May 24 application. This was probably sufficient to break down the cyanamid somewhat, but was not enough to decompose all of it. No more rain fell on these plots until July 7, when all plots were cultivated. Weed control was very good up to this time. By the end of July, the corn on the plots treated May 24 was green and vigorous, while the plants on the plots treated May 18 were yellowing and making no growth. At harvest time the corn plants on the May 18 treated plots averaged more than two feet shorter than the plants treated May 24.

From the data obtained in these experiments it would seem that 400 to 600 pounds of cyanamid applied broadcast shortly before the corn emerges, on medium to light textured soil will control weeds for several weeks. The extra nitrogen furnished by the cyanamid is reflected by increased yields over the checks. In 1948 and 1949, at least one cultivation was shown to be necessary in order to control weeds after the effect of the treatments had worn off. Any residual cyanamid is mixed with the soil, and with better aeration, is made available to the crop.

Summary and Conclusions

1. Three years' results in the use of cyanamid in controlling weeds in corn at the Rhode Island Agricultural Experiment Station are summarized in this paper.
2. Granular cyanamid applied broadcast as a pre-emergence application of 400 to 600 pounds per acre was effective in controlling weeds for several weeks and in furnishing supplemental nitrogen to the crop.
3. One cultivation at least is necessary to control weeds later in the season, the time of cultivation dependent upon the effectiveness of the weed control in any season. This cultivation is also necessary to aerate the soil and to permit the nitrification of any residual cyanamid.
4. Rainfall following applications is the main factor influencing the action of the cyanamid.
5. The use of cyanamid for weed control and to supply additional nitrogen to the corn crop under these conditions appears to be a desirable practice.

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THREE YEARS RESULTS WITH CALCIUM CYANAMID AS A PRE-EMERGENCE TREATMENT ON CORN[1]

C. S. Gould, R. A. Briggs and D. E. Wolf[2]

In 1947 Wolf and Ahlgren[3] of the New Jersey Experiment Station established that the granular form of cyanamid was of superior value to the pulverized form as a weed killer, and that broadcasting cyanamid evenly over the surface was more effective for this purpose than mixing it with the soil. They also presented data showing that cyanamid used for weed control increased the yields of corn. Table I gives some of the results of their experiments.

Table I. Weed control and corn yields resulting from pre-emergence cyanamid treatment[3]

Form of Cyanamid	Treatment	Rate #/A	Weeds/ sq. ft.	% Control	Yield	Av. Yield Treated Plots	Av. Weeds sq. ft. Treated Plots
					Bus/A*	Bus.	
Control	-----	---	81	0	37.1	37.1	81
1 Granulated	Raked	150	46	43	62.5		
2		300	34	70	77.9	72.5	30.3
3		600	11	86	77.0		
4 Granulated	Not	150	43	47	48.9		
5	Raked	300	31	62	67.2	66.2	27.0
6		600	7	91	82.5		
1 Pulverized	Raked	150	57	30	43.3		
2		300	46	63	54.3	56.3	50.0
3		600	47	54	71.4		
4 Pulverized	Not	150	52	36	49.1		
5	Raked	300	37	54	56.0	61.3	37.7
6		600	24	70	78.9		

*Yields throughout this paper are based on No. 2 Yellow Corn at 15.5% moisture.

[1]Acknowledgement is made to the American Cyanamid Company for the support of this project.

[2]Research Fellow in Farm Crops. Extension Associate in Farm Crops. Agent U.S.D.A. and Associate Research Specialist in N. J. Agric. Expt. Sta., respectively.

[3]Wolf, D. E. and G. H. Ahlgren - Jour. Am. Soc. Agron. 40: June, 1949.

Better weed control was obtained with the granular form in both raked and unraked plots. Yield results also favored the granular form.

In 1948, this research was expanded to ascertain the optimum rate of application, and effect of soil type on yield and weed control efficiency. Weed control was good on both the light and heavy soils. (The light soil was a loamy sand and the heavy soil was a loam).

Table II. Weed counts and yields on light soil treated pre-emergence with granular cyanamid. 1948.

Rate/A	Experiment #1 - Applied May 27## Wds/sq. ft.	Experiment #2 - Applied June 10 Wds/sq. ft.	Yield† Bu/A
200	16	57	38.4
400	7	39	47.8
600	7	36	59.4
800	6	29	55.0
Control	44	48	24.6

#Briggs, R. A. and Wolf, D. E. Annual Rpt. to Am. Cyanamid Co. 1948.

##Yields not obtained.

†Difference between means required for statistical significance is 6.3 bu at 5% level and 8.6 bu. at 1% level.

Table III. Weed counts; grain and silage yields on heavy soil treated pre-emergence with granular cyanamid. 1948.

Treatment	Sq. Ft.	Dry Wt. in Pounds Grain	Stalks	Total
200#	13	2,433	5,220	7,655
400	5	2,256	5,287	7,543
600	4	2,129	4,917	7,046
800	5	2,122	4,119	6,241
Check	36	2,776	5,300	8,076

#Briggs, R. A. and Wolf, D. E. Annual Rpt. to Am. Cyanamid Co. 1948.

There was very little difference in weed control between the 400, 600, and 800 pounds per acre applications. On the heavy soils, however, yields were decreased by the higher rates of cyanamid. This may have been due to the excess nitrogen available. Previous fertilizer treatment consisted of 20 tons of cow manure per acre or about 200 pounds of nitrogen plus that added by the cyanamid.

In 1949, tests were conducted to determine the rate of application, time of application and affect of soil type on weed control and corn yield.

The effects of season on the weed killing powers of cyanamid is shown in the following table.

Table IV. Weed control on light soil treated pre-emergence with granular cyanamid.*

A. Treated at planting. Applied May 7, 1949

Rate	Weeds/sq. ft.**	% Control
200#	19.7	19.2
400	11.8	51.6
600	15.2	37.7
800	7.4	69.7
Check	24.4	0.0

B. Treated 4 days after planting. Applied May 12, 1949

200	16.5	32.4
400	7.7	68.4
600	7.4	69.7
800	3.3	86.5
Check	24.4	0.0

C. Treated 7 days after planting. Applied May 14, 1949

200	12.3	49.6
400	3.5	85.6
600	1.7	93.0
800	.3.7	84.8
Check	24.4	0.0

*Loamy Sand

**Average of three replications

Weed counts were taken one month after planting. The desirability of the delayed application is quite apparent from the standpoint of weed control. Injury was noted on some of the plots treated 7 days after planting at the 800 pound rate but the damage was not uniform in all replications.

On a clay loam soil the same trend in weed killing power was apparent. This is shown in Table V.

Talbe V. Weed counts on heavy soil treated pre-emergence with granular cyanamid.

A. Treated 3 days after planting. May 12, 1949

Rate	Weeds/sq. ft.	% Control
200#	37.6	30.4
400	54.9	-1.7
600	33.4	38.1
800	42.3	21.6
Check	54.0	0.0

B. Treated 7 days after planting. May 16, 1949

Rate	Weeds/sq. ft.	% Control
200	47.6	11.8
400	27.0	50.0
600	14.3	73.5
800	16.3	69.8
Check	54.0	0.0

The higher percentage control on the light soil may be due to a greater rapidity of weed seed germination.

The 1949 yield data is shown in the following tables.

Table VI. Yields of corn growing in a light soil* treated pre-emergence with cyanamid.

A. Treated at planting. May 7, 1949

Rate	Yield, Bu/A.**
200	59.1
400	64.3
600	61.7
800	64.0
Check	43.4

Total rainfall for June, July and August at New Brunswick 5.78 inches approx.

B. 4 days after planting. May 12, 1949

Rate	Yield, Bu/A.
200	69.4
400	65.3
600	62.9
800	70.9
Check	50.2

C. 7 days after planting. May 14, 1949

Rate	Yield, Bu/A.
200	61.8
400	60.8
600	67.8
800	54.3
Check	45.9

*Loamy soil.
**Average of 3 replications.

Table VII. Yield of cyanamid treated corn growing in heavy soil.*

A. Treated 4 days after planting. May 12, 1949

Rate	Yield, Bu/A.**
200	71.9
400	62.4
600	64.7
800	70.4
Check	83.4

B. Treated 8 days after planting. May 16, 1949

200	70.1
400	73.8
600	75.3
800	87.8
Check	83.4

*Loamy soil.

**Average of 3 replications.

Protein determinations were made on the grain and silage. Indications from the 1948 tests are that protein content of grain and stalk is increased with increased rates of cyanamid. The 1949 protein determinations are not yet ready.

Summary

1. Granular cyanamid is effective as a weed killer when used as a pre-emergence treatment on corn.

2. Its use should be limited to light soils, since the higher rates of application may cause some reduction in yield on heavy soils.

3. Increased yields can be expected when rainfall is plentiful. And when added nitrogen can be efficiently used.

4. The 400 pounds per acre application is the most practical rate because weed control efficiency is not increased appreciably with higher applications. There is also some danger of injury to the corn at these rates.

5. Delayed applications of cyanamid are more effective in controlling weeds than applications made at the time of planting.

Controlling Weeds in Corn with 2,4-D[1]

F. B. Muller and T. E. Odland[2]

An experiment was initiated in 1948 at the Rhode Island Experiment Station in the use of 2,4-D for the control of weeds in field corn. The chemical was used for both pre-emergence and post-emergence treatments. The experiment was continued in 1949 with some modifications in rates and amount of supplemental cultivation. The soil where these tests were located is classified as Bridgehampton very fine sandy loam. It is in a high state of fertility. The results from the two years of the experiment are reported in this paper.

Many experiments have been conducted with 2,4-D for the control of weeds in field corn. (1, 2, 3, 4, 5) The results have varied considerably. In some cases the control has been excellent while in others the value of the treatments has been questionable. Many factors such as time and amount of material, 2,4-D type, corn variety, soil type and weather conditions have been found to influence the effectiveness of 2,4-D when used for weed control in field corn.

Materials and Methods

In both 1948 and 1949, Ohio K-24 hybrid corn was used. The fertilizer in 1948 consisted of 1,000 pounds per acre of a 4-12-8 grade. In 1949 the same amount of an 8-12-12 was used. In both years the butyl ester of 2,4-D was used for all applications, diluted with water to be equivalent to 5 gallons of spray per acre. The corn was planted May 19 both years and harvested in the first week of October.

In 1948, four rates of application were made at four different times in relation to the stage of growth of the corn. Rates of 1/2, 1, 1-1/2 and 2 pounds of acid equivalent per acre were applied at pre-emergence, at emergence, when the corn plants were 2-4 inches high, and when the plants were 12-15 inches high. This latter application was made on plots previously treated at pre-emergence. Weed counts were made when the weeds in the check plots were about two inches high. The plots consisted of 5 rows planted 3 feet apart and 19 feet long with three replicates for each treatment.

In 1949, three rates of application of 2,4-D were used at each of three different dates. One, 2 and 3 pounds per acre of acid equivalent were applied at pre-emergence; 1/4, 1/2 and 1 pound when the plants were 2 to 4 inches high, and 1/8, 1/4 and 1/2 pound when the corn was about 12 inches high. Since such poor results were obtained in 1948 on the non-cultivated plots, all plots received either one or two cultivations in 1949. In addition, one set of plots received three cultivations. The sprays were applied on the following dates: pre-emergence, May 22; 2-4" high, June 9; 12" high, June 24. The plot size

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[1]Contribution No. 753 of the Rhode Island Agr. Exp. Station, Kingston, R.I.
[2]Graduate Assistant and Head, Department of Agronomy, respectively.

was the same as 1948 but there were 4 instead of 3 replicates of each treatment.

The 1948 growing season at Kingston was characterized by a cold, wet spring which retarted planting and early growth. The May rainfall was more than double the normal. From mid-July to mid-September a severe drought affected all crops. The heavy rains in May compacted the soil so that the non-cultivated corn suffered from lack of aeration throughout the season.

The 1949 season was the most deficient in rainfall at Kingston in more than 50 years. The dry spell began in May and continued until the last of August. This made soil conditions much different than in 1948. The early cultivation was not as necessary for soil aeration. Table 1 shows the monthly record of rainfall for the two seasons.

Table 1. Monthly rainfall in inches for the 1948 and 1949 growing seasons at Kingston, R. I.

	April	May	June	July	Aug.	Sept.	Total
Normal	3.93	3.07	3.66	2.42	4.08	3.80	20.96
1948	4.20	8.61	2.37	1.87	0.79	0.96	18.80
1949	4.57	2.63	0.04	1.89	2.51	4.02	15.66

Results

Table 2 shows the relative amount of surface area covered by weeds, percentage of grass weeds and amount of injury for each treatment in 1948.

At the rates of 2,4-D applied, the most effective time of application appeared to be when the corn was 2-4" high which is when the weeds were starting to germinate. Weed control was very effective for nearly six weeks. However, severe injury resulted, even at the 1/2 lb. rate. Considerable rain fell after the pre-emergence application, contributing to less weed control. The emergence spray, June 2, was applied when the soil was nearly saturated from heavy rains. The June 10 application was also made when the soil moisture was fairly high but was followed by a long period of deficient rainfall. The rain which fell subsequently was not sufficient to wash the 2,4-D down very far. One possible cause for the severe injury on the 2-4" high treatment was the soil conditions before and during application. The heavy rains of May waterlogged the soils so that in early June the soil was still extremely wet and the corn roots were concentrated near the surface. This brought them in contact with the 2,4-D which was washed down throughout the same shallow soil zone by the subsequent showers.

Table 2. Weed control in corn with 2,4-D - 1948

Treatment		Amount of weeds*	% grasses	Injury
Pre-emergence	1/2**	4	27	None
"	1	4	33	None
"	1-1/2	3	53	None
"	2	2	70	V. Sl.
Emergence	1/2	3	36	None
"	1	3	57	None
"	1-1/2	2	55	None
"	2	1	60	V. Sl.
Corn 2-4" High	1/2	2	45	Consid.
" " "	1	2	60	Severe
" " "	1-1/2	1	45	Severe
" " "	2	2	70	Severe
P. E. and 12" High	1/2 & 1/2	4	45	Slight
" " " "	1 & 1	3	50	Slight
" " " "	1-1/2 & 1-1/2	3	60	Consid.
" " " "	2 & 2	3	65	Consid.
No 2,4-D		5	40	----

* 0= no weeds; 5=100% of surface covered. The following weeds were noted when the counts were made on July 6: Crabgrass, foxtail, quackgrass, nutgrass, ragweed, smartweed, chickweed, pigweed and purslane.
**Pounds per acre of acid equivalent in butyl ester form.

The 12-15 inch high application, June 24, was not complicated by soil conditions as were the previous treatments. The ground was covered with weeds, and the corn leaves presented a fairly large surface area, so that very little 2,4-D reached the ground. Subsequent rainfall was far below normal, and little 2,4-D was washed off the plants onto the soil. What 2,4-D was taken up by the corn plants was as a result of the direct application to the leaves and was not increased by being taken up by the roots. In contrast with the three previous applications which were essentially applied before or at the time the weeds came up, the last application was a typical post-emergence application; i.e. applied to the weeds in growing corn. The corn responded to this application by leaning over and becoming very brittle, but apparently the dosage was not sufficient to cause permanent injury, as the plants recovered in a few weeks.

The yields obtained in 1948 are presented in Table 3. The yields on the non-cultivated plots were less than half that of the plots receiving two cultivations, even though the first cultivation was not made until July 3. Severe injury to the corn at the 2-4 inches high stage is reflected in the lowered yields at all rates of application. While considerable injury resulted from the 12-15 inches high spray, evidently this injury was not permanent, except at the two-pound rate.

Table 3. Yields in bushels of shelled corn per acre on 2,4-D experiment in 1948 at Kingston, R. I.

Treatment		Not Cultivated	Two Cultivations
Pre-emergence	1/2*	9.4	39.5
"	1	10.0	45.1
"	1-1/2	24.2	45.9
"	2	29.4	64.4
Emergence	1/2	20.6	56.9
"	1	19.4	52.4
"	1-1/2	31.8	56.2
"	2	32.8	37.3
2-4" High	1/2	13.4	31.7
"	1	16.0	31.5
"	1-1/2	15.3	24.8
"	2	15.9	39.4
P. E. & 12" High	1/2 & 1/2	15.0	48.2
"	1 & 1	21.8	43.9
"	1-1/2 & 1-1/2	25.0	59.7
"	2 & 2	25.9	32.7
No 2,4-D		12.5	39.2
Averages			
Pre-emergence		16.2	46.0
Emergence		22.7	48.3
2-4" High		16.0	34.1
P. E. & 12" High		20.3	45.0
LSD .05 between times		3.3	6.4
" rates		6.1	11.4

*Pounds per acre of acid equivalent (Ester)

Weed control for 1949 is summarized in Table 4. Excellent control of all weeds was obtained in the pre-emergence treatments. In the post-emergence treatments, good control of broadleaved weeds was obtained, while the grasses were controlled only to a slight extent. The 12" high application was effective for most of the broadleaved plants, which made up the greater part of the weed population, but had no effect on the grasses. Practically no injury to the corn was observed in 1949. Rainfall was evenly distributed in the spring, and the soil was at no time near saturation.

Table 4. Weed control in corn with 2,4-D in 1949.

Treatment		Amt. of Weeds*	Percent grasses
Pre-emergence	1**	3	25
"	2	2	10
"	3	1	3
Corn 4" High	1/4	3	20
"	1/2	2	50
"	1	2	55
Corn 12" High	1/8	4	30
"	1/4	4	15
"	1/2	4	15
No 2,4-D		5	22

* 0=no weeds; 5=100% of surface covered. The following weeds were noted when the counts were made on June 21: Crabgrass, corngrass, purslane, ragweed, pigweed, spurry.
**Pounds per acre of acid equivalent (Ester)

The yields obtained in 1949 are shown in Table 5. The yields ranged from 50 to 100 bushels of shelled corn per acre. The highest yields were obtained at the 4" high application of one pound 2,4-D. Very little injury resulted at this stage, as evidenced by onion-leaf effect and brace root aberration. Three pounds applied at pre-emergence gave the second highest yield. Yields of corn sprayed when a foot high were considerably lower than those from other times of application, probably due to delayed weed control, and lack of control of grasses at this late date. The higher rates of application of 2,4-D at pre-emergence and shortly after emergence eliminated the necessity for one hoeing or cultivation.

Table 5. Yields on 2,4-D experiment in 1949 at Kingston, R. I. in bushels of shelled corn per acre.

Treatment	Cultivated once	Cultivated twice
Pre-emergence 1	72.2	86.9
" 2	82.8	80.0
" 3	91.8	98.3
Corn 4" High 1/4	80.8	82.2
" 1/2	81.5	92.1
" 1	98.3	100.8
Corn 12" High 1/8	58.0	80.2
" 1/4	65.2	79.8
" 1/2	61.5	80.3
No 2,4-D	52.4	69.6
Averages		
Pre-emergence - all rates	82.3	88.4
4" High "	86.9	91.7
12" High "	61.6	80.1
Average all treatments	76.9	86.7
No 2,4-D (3 cultivations)		(90.9)
LSD at 5%	23.8	21.2

Discussion

The variations in yields, in weed control and in injury to the corn plants in different growing seasons are difficult to account for, though in the main they appear to be related to soil conditions before, during and after applying the chemical. In 1948, the soil was thoroughly wet, so wet in fact that the emergence spray had to be delayed two days. The weather was generally cloudy and cold during the first two weeks in June, and the corn was considerably retarded. While it is generally thought that low temperatures and cloudy weather hinder the effectiveness of 2,4-D, in 1948 the effectiveness was so great that the corn was severely injured.

Even where weed control was good, yields were extremely low where no cultivation was done. The heavy spring rains compacted the soil, and the subsequent drought formed a hard crust over the soil surface, preventing proper aeration for root growth and nitrification. The heavy showers no doubt leached a considerable portion of the nitrates from the soil. In 1948, cultivation was necessary if for no other reason than to allow for proper aeration.

In 1949, the spring rains were evenly distributed, and the soil was moist, but not wet at the pre-emergence application. Rainfall amounted to .47 inch within the week following the application. No rain fell after the 4 inch high treatments of June 9 until a month later, and then only a light rain. The 2,4-D applied stayed near the surface, weed control was good, and no injury to the corn resulted.

Later applications of 2,4-D, when the corn was about a foot high, was effective in controlling broadleaved weeds but had no apparent effect upon grasses. With light rates used at this stage there is less chance of injury but also less weed control.

Better weed control may be obtained at pre-emergence or just post-emergence, since annual grasses are also controlled to quite an extent, and heavier rates of 2,4-D may be used. However, the chances of injury are also greater, and before general recommendations can be made for the use of heavier rates of 2,4-D, more research needs to be made on the soil conditions leading to injury and poor weed control.

Summary and Conclusions

1. Two years' results in the use of 2,4-D in controlling weeds in corn are summarized.
2. Severe injury to the corn plants resulted from spraying when the crop was about 4 inches high in 1948 but not in 1949. The cause of this injury is probably related to soil conditions preceding and following application.
3. Weed control is most effective when applied at pre-emergence or shortly after emergence, since more chemical may be applied, and grasses as well as broadleaved weeds may be killed.
4. More research is necessary to determine how soil conditions effect the toxicity of 2,4-D.

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Acknowledgment

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A Comparison of the Effectiveness of Certain Chemicals in Controlling Horse Nettle and Other Weeds in Corn

Homer B. Neville[1]

The work presented here is primarily concerned with the control of horse nettle (Solanum carolinense). Effects on other weeds are incidental. Those included in the observations are Lambs quarters (chenopodium album), red-root pigweed (amaranthus retroflexus), nut grass (Cyperus esarlentus), curled dock (Runex crispus) and wild mustard (brassica arevensis). Not all of these weeds existed in every plot treated.

Plan of Experiment

Applications were timed for pre-emergence on corn grown on light and heavy soils and post emergence on corn, treated during dry soil conditions and following a rainy period. In the pre-emergence treatments, materials were applied as the corn seedlings were beginning to break ground. Horse Nettle was present in all plots, though it had not emerged at the time of the pre-emergence treatment. Six chemicals were used. All chemicals containing 2,4-D were applied at the rates of 1, 2 and 3 pounds of the acid-equivalent per acre Cyanamid, at the rates of 75 pounds and 150 pounds per acre and PX 40 A at the rates of 1 gallon and 2 gallons per acre were used only in pre-emergence treatments. Plots were laid out on Sassafras sandy loam and on Boynton gravelly silt loam. All treatments were replicated three times.

Results.

Table I. Pre-Emergence on Corn Grown on Sassafras Sandy Loam

Chemical	Rate Per A.	(1) Weed Control (except Horse Nettle & Nut Grass) %	Horse Nettle and Nut Grass	Effect on Corn
Weed-No-More (40)	1 lb. acid	95	0	None
(2,4-D-Ester)	3 lbs. "	100	0	"
Weed-Kill	1 lb. "	90	0	"
(2,4-D Amine)	3 lbs. "	100	0	"
(2) Tat-C-Lect (PMAS))	1 2/3 gal.	50	0	"
Weed-C-Lect (2,4-D))	3 1/3 gal.	60	0	"
PX 40 A	1 gal.	100	0	"
	2 gal.	100	0	"
Cyanamid	75 lbs.	50	0	stimulated
	150 lbs.	75	0	"
Checks	Cultivated	90 between rows 0 in the row		Normal

[1]Senior Instructor, Department of Agronomy and Farm Management, Long Island Agricultural and Technical Institute, Farmingdale, N. Y.

Table II. (3) Pre-emergence on Corn grown on Boynton silt loam.

Chemical	Rate per A.	(1) Weed Control Nut grass %	Horse Nettle %	All Others %	Effect on Corn
Weed-No-More	1 lb. Acid	0	0	95	None
	2 lbs. "	0	(4) 10	100	(5) 10
Weed-Kill	1 " "	0	0	90	None
	2 " "	0	0	100	"
Tat-C-Lect)	1 2/3 gal.	0	0	30	"
plus)					
Weed-C-Lect)	3 1/3 gal.	0	0	50	"
P X 40 A	1 gal.	0	0	100	(5) 10
	2 gal.	0	0	100	20
Sherwill Kill	½ lb. acid	0	0	85	0
(2,4-D/2,4,5-T)	1 lb. acid	0	(4) 10	100	0
Checks	Cultivated	75	80	90 between rows	
		0	0	0 in the row	

Table III *Post-Emergence on Corn grown on the Sassafras Sandy Loam

Chemical	Rate per A. lb. acid equiv.	***Weed Control % Injury (Horse Nettle)	**Effect on Corn dry soil	moist soil
Sherwill Kill	½	0	None	None
(2,4-D/ 2,4,5T)	1	50	None	Slight on Adv. roots
	2	80	Adv. roots stimulated	stems and adv. roots
	3	80	"	"
Esteron 44	½	0	None	None
(2,4-D Ester)	1	20	None	Slight on adv. roots
Checks	Not cultivated	0		Dwarfed

(1) Weed control is expressed in terms of per cent as compared with the average of the checks. The period of control lasted for 5 to 6 weeks except those plots in which control was less than 90%. Observations on weeds were made 6 weeks after treatment. Horse nettle and nut grass emerged within two weeks after treatment and grew normally.

(2) Tat-C-Lect was mixed with Weed-C-Lect in the ratio of 2:1 by volume.

(3) On the date of application many corn plants were up about 1 inch and were hit by the spray.

(4) Plants were not killed but showed deformations characteristic of 2,4-D injury. Probably the growing tips had emerged at the time of treatment. They later recovered and grew normally.

(5) Slight injury to the corn plants was evidenced by the twisting of the leaves in the 2,4-D plots. In the PX 40 A plots the plants showed slight "burning" at the tips and margins of the leaves and the plants showed symptoms of stunted growth thru out the season.

* The variety of corn grown was U.S. 13. Two series of plots were treated. The first series was treated on July 8 at which time the corn was 30 inches tall. The soil was dry at the time and no rain fell for the next 2 weeks. The second series of plots was treated on July 23 following a 1" rainfall. The spray was applied at the rate of 80 gallons per acre. Nozzles were adjusted so as to hit only the base of the corn plants.

** Following the first treatment the only noticeable effect on the corn was some slight stimulation of the adventitious roots. However, after the July 23 treatment many plants showed the characteristic deformed growth and brittleness of stem. Stimulation of the adventitious roots was more pronounced than in the earlier treated plots. At harvest time, though no actual yield tests were made, there was no apparent difference in growth between any of the treated plots and the checks.

*** In the post-emergence treatments no attempt was made to evaluate the control of weeds other than horse nettle. At the 1 lb. rate the stems of the plants were slightly twisted and the leaves slightly yellowed. They soon recovered. At the 2 and 3 lb. rates, some plants died, others remained alive but stunted thru out the season. They failed to produce any seed heads.

Conclusions.

1. Pre-emergence treatment by any of the chemicals used will not control horse nettle.

2. PX 40 A is as effective in control of weeds thru pre-emergence treatment as are the butyl ester and amine formulations of 2, 4-D.

3. PX 40 A injures corn in the seedling stage.

4. A combination of 2,4-D and 2, 4, 5-T is more effective on horse nettle than the isopropyl ester of 2, 4-D.

5. The 2, 4-D - 2, 4, 5-T formulation can be used safely on growing corn provided the spray is directed at the base of the plants only, and application is made when climatic or soil conditions check the rapid growth of corn.

6. Results on horse nettle are not satisfactory but show enough promise to warrant further work. Where corn can be harvested in early September a second application on the weeds, immediately after the harvest of the crop might prove more effective.

Preliminary Results on the Use of Wetting Agents with Crabgrass Killers[1]

Earl E. Walter and Dale E. Wolf[2]

Wetting agents and related surface active agents have been used for years in the textile and allied industries. Applying these to agricultural uses has just recently been found effective.

In 1948, in crabgrass control tests at the New Jersey Agricultural Experiment Station Ralph E. Engel[3] and Dale E. Wolf found that potassium cyanate was an effective crabgrass killer when used with a wetting agent. This opens up new possibilities for combating weeds.

Wetting agents can be defined as any substance or substances which when added to surface coatings, water or oils, increases the spreading and penetrating action of the solution due to the lowering of 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.

Most investigators agree that the degree to which a solid body is wet by a liquid may best be measured by the contact angle at the liquid-solid-air line. If the contact angle is zero, the solid is completely wet. Contact angles greater than 90 degrees indicate that the solid is difficult to wet by the particular liquid being examined.

Interfacial tension, and also surface tension, may be materially lessened by the use of surface active agents, among which are the wetting agent group.

In 1949, wetting agents supplied by the General Dyestuff Corporation were tested extensively at the New Jersey Experiment Station in combination with crabgrass killers. The crabgrass killers and the wetting agents were used in widely varied concentrations in an effort to determine selectivity in weed killing and any resulting damage to turfed areas.

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1 Acknowledgement is made for partial support of this project to the General Dyestuff Corporation, New York City, N. Y.

2 Research Fellow, Department of Farm Crops and Agent U.S.D.A., Associate Research Specialist N. J. Agric. Expt. Sta., respectively.

3 Research Associate, Department of Farm Crops.

Differences in wetting agents might be expected in weed control since certain wetting agents wet some plant species better than others and all types of wetting agents are not chemically compatible in solution with all types of herbicides.

Methods

A. Different concentrations of the wetting agents were tested ranging from a low of .025% to a high of .5%.

B. The combination of various wetting agents with known weed killers were tested to determine the selective effectiveness.

C. Turf plots heavily infested with crabgrass (Digitaria sanguinalis) were treated to determine percentage of control and any resulting turf injury.

In 1949, the tests were conducted on replicated plots 4' x 15', leaving one foot between each plot.

The sprayer used was designed by Mark E. Singley[4] and Dale E. Wolf of the New Jersey Agricultural Experiment Station. It consists of a two tank mounted pressure sprayer with rubber hoses and a boom with four nozzles handled individually to permit even coverage of the plots. Two-quart jars are used as the spray tank. A pressure of 40 pounds on the four nozzles was used and the volume was 360 gallons of solution per acre. Percentage of concentration of the wetting agents was computed to 100% active ingredient.

Results

The 1948 crabgrass control tests conducted by Engel and Wolf provided the basis for the 1949 tests. Their work and a range of concentrations of contact killers, such as potassium cyanate,[5] indicated that 16# per acre KOCN with a wetting agent gave good control under most conditions.

Table 1 indicates the marked differences in the use of KOCN with and without a wetting agent. Vatsol K[5], used as the wetting agent, showed good control of crabgrass in all replicated plots.

The 1949 results of wetting agents supplied by the General Dyestuff Corporation are shown in Tables 2 and 3.

The basis for judging the materials was by the selectivity accomplished. The two deciding factors were crabgrass control and turf injury.

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[4]Associate Prof. Ag. Engineering, N. J. Agric. Expt. Sta.

[5]Acknowledgement is made to the American Cyanamid Company for supplying this material.

Table 1. The effect of Vatsol K with Potassium Cyanate and Ammonium Sulfate on the control of crabgrass.**

Treatment			No. of Treat-ments	Rate	Average Crabgrass Control	Average Turf Injury
Check					0	0
Phenyl mercuric acetate			3	13oz/1000	72	.3
Ammonium Sulphate			1	16lb/1000	27	3.5
"	"	Wa*	1	16 "	93	4
"	"		2	8 "	35	3.9
"	"	Wa	2	8 "	99	3.5
"	"		3	5-1/3"	43	1.1
"	"	Wa	3	5-1/3"	91	2.5
Potassium Cyanate			2	8lbs/A	46	.7
"	"	Wa	2	8 "	77	.8
"	"		1	16 "	54	.8
"	"	Wa	1	16 "	84	1.3
"	"		2	16 "	75	.9
"	"	Wa	2	16 "	89	1.2
"	"		1	32 "	68	1.2
"	"	Wa	1	32 "	89	1.9

*Wa refers to wetting agent -(Vatsol K was used as the wetting agent in this test at the rate of .25% solution.)
**From work conducted by Ralph E. Engel and Dale E. Wolf
1st treatment August 6, 1949.
2nd " August 15, 1949.
3rd " August 24, 1949.

Three members of the Farm Crops Department, Rutgers University, individually compiled the percentages of crabgrass control and turf injury. These results were then combined to give the average percentage of control. The turf injury was determined on a scale of: no injury 0, slight 1, moderate 2, severe 3, and kill 4.

Conclusions

Various wetting agents were applied with weed killers to turf areas, and results indicate there is a definite place for wetting agents as used with some crabgrass killers. The effective action of the wetting agents is that of lowering the surface tension to the point where maximum selective benefits can be obtained.

A. Some wetting agents when used with potassium cyanate resulted in the killing of crabgrass (Digitaria sanguinalis) without killing the mixture of turf grasses which was predominantly Kentucky bluegrass (Poa pratensis).

Table 2. The effect of various wetting agents with Potassium Cyanate on the control of crabgrass.

Wetting Agent	Rate Conc. of W. A. %	Average Crabgrass Control %	Average Turf Injury	Date of Application
1 NEKALNS	.025	77	0	Aug. 17
2 "	.025	87	0	" 25
3 "	.05	87	1.33	Sept. 12
4 "	.1	88	1	Aug. 25
5 "	.1	81	1	Sept. 12
6 "	.25	94	1	" 12
7 "	.5	97	.33	Aug. 25
1 IGEPON A.P. EXTRA CONC.	.025	95	2	Aug. 17
2 "	.025	90	0	" 25
3 "	.05	95	1.33	Sept. 12
4 "	.1	92	0	Aug. 25
5 "	.1	83	1.66	Sept. 12
6 "	.25	91	2.33	Sept. 12
7 "	.5	98	.66	Aug. 25
1 IGEPAL CA EXTRA CONC.	.025	85	1	Aug. 17
2 "	.025	88	.33	" 25
3 "	.05	83	.2	Sept. 12
4 "	.1	88	.33	Aug. 25
5 "	.1	81	1.66	Sept. 12
6 "	.25	93	1.33	Sept. 12
7 "	.5	95	.33	Aug. 25
1 CORIKAL B	.025	91	1	Aug. 17
2 "	.025	53	0	" 25
3 "	.05	91	1.66	Sept. 12
4 "	.1	87	.33	Aug. 25
5 "	.1	88	1	Sept. 12
6 "	.25	86	1	Sept. 12
7 "	.5	95	.33	Aug. 25
1 VATSOL K*	.025	87	2	Aug. 25
2 "	.05	91	1.66	Sept. 12
3 "	.1	80	2.66	Aug. 25
4 "	.1	88	2.33	Sept. 12
5 "	.25	79	1	Aug. 17
6 "	.25	90	1.33	Sept. 12
7 "	.5	94	2	Aug. 25

*American Cyanamid Co.
Preliminary results of wetting agents used at 16#/A KOCN in 360 gal of H_2O

Table 3. The effect of various wetting agents with Potassium Cyanate on the control of crabgrass.

	Wetting Agent	Rate Conc. of W. A.	Average Crabgrass Control	Average Turf Injury	Date of Application
1	NEKAL A	.025	72	2	Aug. 17
2	"	.05	88	4	" 17
1	IGEPON T	.025	73	1	Aug. 17
2	"	.05	92	4	" 17
1	SORAPON SF	.025	85	1	Aug. 17
2	"	.025	72	1	Aug. 17
1	PRESTABIT OIL V NEW	.025	53	1	Aug. 17
1	NULLAPON BFC Liquid	.25	88	1.66	Sept. 12
2	NULLAPON BFC Conc.	.25	75	1	Sept. 12
3	NULLAPON BFC Acid	.25	70	1	Sept. 12
1	KOCN (Alone)		46	2	Aug. 17
2	" "		83	1.66	Sept. 12

B. The concentrations of wetting agents seemed to be most satisfactory at .025% since the turf injury was much less. Only when the .025% rate was increased to .5% (or 20 times the lowest concentration) did the control appear much better.

C. Several of the wetting agents increased selectivity.

D. Preliminary results with IGEPON AP EXTRA CONC. and potassium cyanate appear to be giving the best crabgrass control with the lowest concentration used. More research is being done with some of the wetting agents that had only one or two tests due to the short dry summer. All wetting agents will be tested more extensively next year.

E. Wetting agents are easy to handle and most surface active agents are non-injurious to the skin.

F. The economical and efficient use of wetting agents with some herbicides seems to be very advantageous.

EXPERIMENTS IN CRABGRASS CONTROL WITH POTASSIUM CYANATE

E. C. Nutter and J. F. Cornman[1]

A. INTRODUCTION

Numerous chemicals have been used in the past in attempts to control crabgrass (*Digitaria sanguinalis*) in turf. A few of these have been used somewhat successfully. However, associated with the use of these few chemicals have been certain undesirable features such as burn or corrosive injury to the turf grasses, toxicity to the handler, difficulty of getting material into solution, or prohibitive cost when applied on a large scale. Thus such chemicals must be used under limited conditions and/or by carefully trained personnel.

Potassium cyanate (marketed as "Aero-Cyanate"[2]) has shown promise toward the selective control of crabgrass in turf as well as toward overcoming some of the undesirable features mentioned above. This chemical has been under field test during the past summer to determine its effectiveness as a herbicide for control of crabgrass in turf.

The following is a report on the results of these experiments.

B. METHOD AND MATERIALS

The experimental sites were chosen in the more heavily infested crabgrass zone of New York State (at Kensico Cemetery and the Westchester Country Club in Westchester County and at the Piping Rock Club, Locust Valley, in Nassau County). Plot size was 1/100 acre (10' X 43.6').

Results of preliminary investigations at New Jersey (1) and elsewhere in 1948 indicated that rates from 4 pounds per acre (lbs/A) to 32 lbs/A of Potassium Cyanate showed most promise for crabgrass control. Thus rates of chemical were selected for this experiment to include 4,8,16, and 32 lbs/A of KOCN. All applications were in the liquid form.

Applications of chemical in volumes of water varying from 10 to 200 gallons per acre (g.p.a.) were tested in this experiment. High volumes (100 to 400 g.p.a.) of liquid were indicated as most favorable from preliminary studies, but lower gallonages were included because of the practicality of these lower volumes from the standpoint of large scale application.

Because of the importance of controlled and uniform distribution of spray material, an experimental weed sprayer was built which included the following features:

(1) Constant flow of material using Co_2 pressure regulated at 30 pounds per square inch.
(2) Constant width of coverage by a carefully engineered ten foot spray boom.
(3) Uniform rate of travel calibrated by a specially geared odometer which permitted precise calibration and application.

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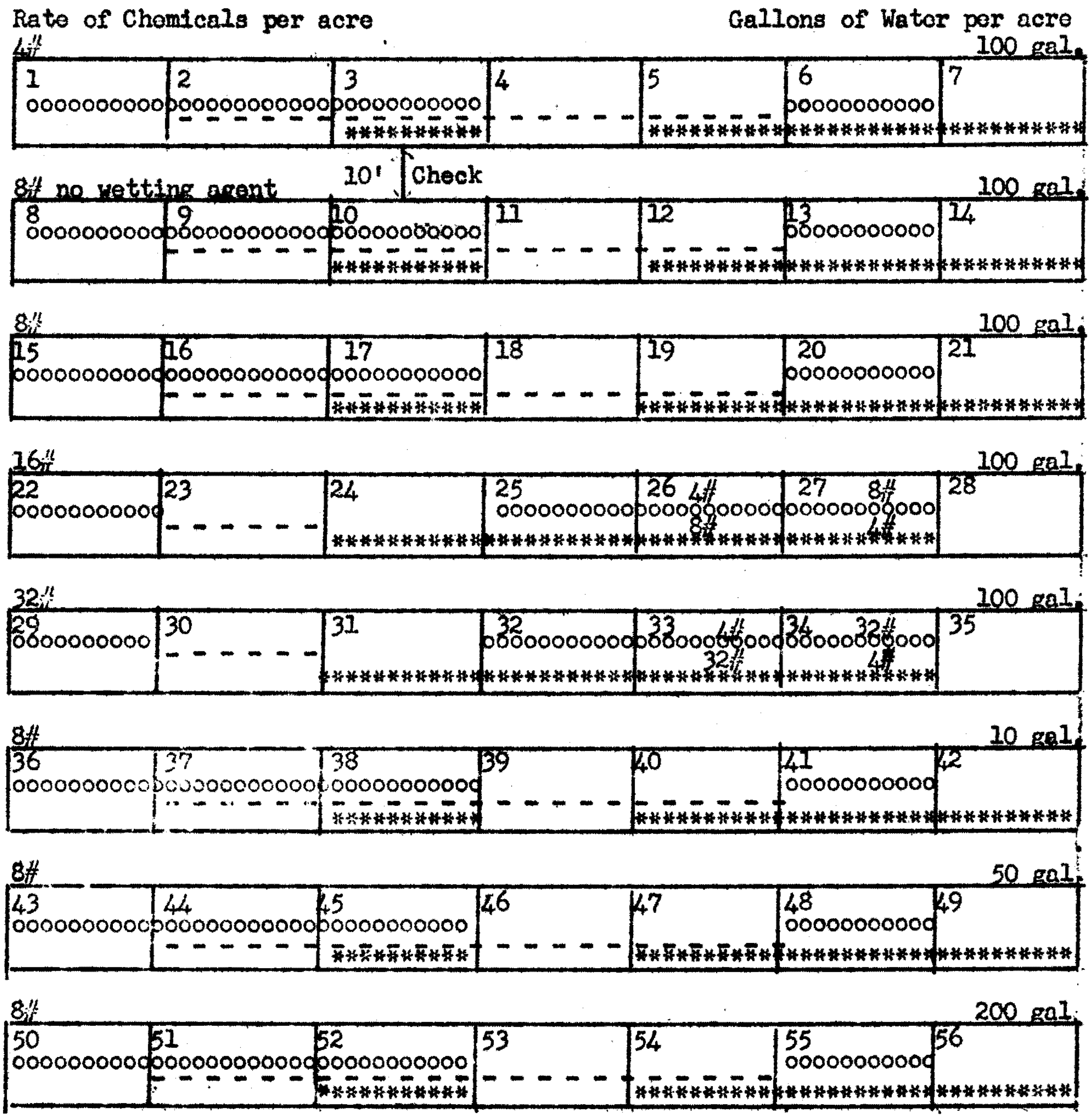
[1]Research Assistant in turf and Assistant Professor in Ornamental Horticulture respectively, N. Y. State College of Agriculture, Cornell University, Ithaca, N.Y.
[2]Courtesy of the American Cyanamid Company.

The experiment was resolved into two series. The first and more extensive series began July 25 (at which time the crabgrass plants were in the two leaf stage of growth) and continued at two week intervals until three treatments had been applied. The earlier series of the experiment was carried out during the prolonged drought period suffered in this vicinity of the East Coast (July through Mid-August, 1949). Figure 1 shows the general treatment plan of this series.

FIGURE I TREATMENT PLAN SERIES I



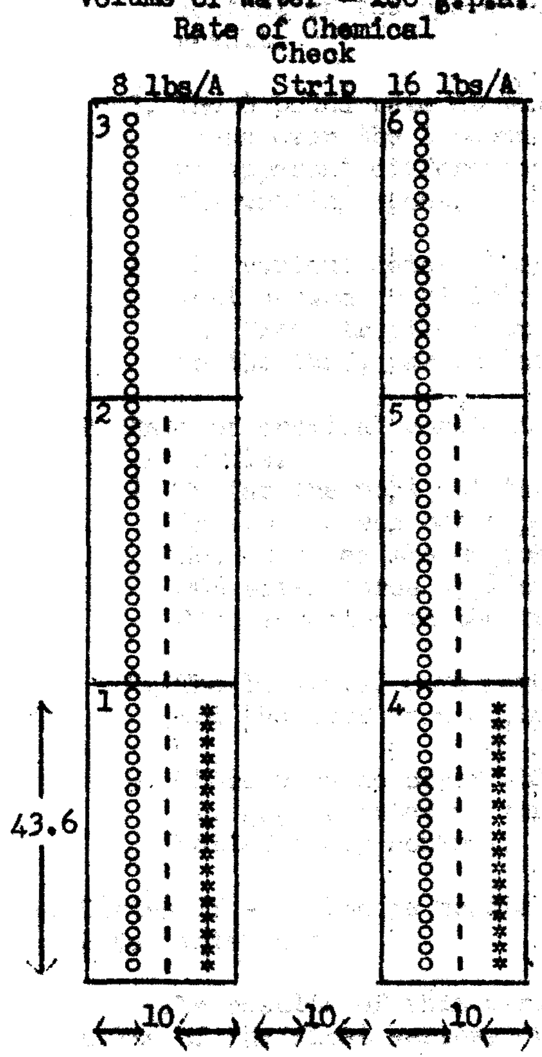
KEY: oooooooooooooooooo 1st. Application
- - - - - - - - - - 2nd. Application
****************** 3rd. Application
Plot size 10' X 43.6' = 1/100 Acre Check Plots 10' X 43.5' = 1/100 Acre

In one phase of the first series the volume of water remained constant (100 g.p.a.) and rates of chemical were varied, while in a second phase, the rate of chemical was held constant (8 lbs/A) while the gallonage varied. As illustrated in Figure 1, various combinations were included involving time and number of applications. A wetting agent (0.3% Vatsol K) was included in all treatments except plots 8 through 14. As indicated in Figure 1, check strips 10 feet wide were alternated with each row of treated plots.

The second series of the experiment was an out-growth of the results of the first series and of observations made at other stations. From these observations it was decided that treatment intervals of two weeks and greater were possibly too long, therefore, a second series of treatments was begun August 30 (as the crabgrass was entering the seed head stage of growth) using rates of chemical of 8 and 16 lbs/A in three successive applications at two day intervals. By this time the extended drought period had been broken, temperatures were lower and the general growing condition of the grass was more favorable. Figure II shows the general treatment plan of this second series of plots.

FIGURE II   TREATMENT PLAN SERIES II

Volume of Water - 100 g.p.a.



KEY: oooooooooooo 1st Application (Aug. 30)
- - - - - - 2nd Application (Sept.1)
*********** 3rd Application (Sept.3)

Plot Size, 10' X 43.6' = 1/100 Acre
Check strip 10' wide

C RESULTS

For the purposes of this experiment 85% or more reduction in the crabgrass stand was considered satisfactory control. Methods of evaluation used in this experiment were observation, where differences were obvious, and a modification of the String Method as described by Tinney, et. al. (2) where direct counts were required.

1. Series I

   a. Gallonage constant (100 g.p.a.)- rate of chemical varied - 2 week intervals.

      1. At 100 g.p.a. of water 16 and 32 lbs/A of chemical showed the greatest control of crabgrass but not enough to be considered as satisfactory control. The turf was seriously discolored by these applications, particularly at the 32 pound rate. Two applications of 32 lbs/A showed greater control of crabgrass and correspondingly greater injury to the turf than the single application of this rate.

      2. No combinations of the 4 pound level of treatment gave satisfactory control of the crabgrass, nor did lasting injury to the turf grasses result.

      3. The 8 pound rate at this gallonage showed increased control of crabgrass over the 4 pound rate but not satisfactorily so. There were no apparent differences between the 8 pound rates with and without the wetting agent.

      4. The various dates of application within a particular rate of treatment showed no visible differences in degree of control. However, the first treatment on July 25 showed the highest degree of injury to the turf, particularly at the higher rates.

   b. Rate of chemical constant (8 lbs/A) - Gallonage Variable - 2 week intervals.

      1. By far the most outstanding set of plots in this first series of treatments was the 8 pound rate of chemical applied at 200 g.p.a. Not only was the degree of control of crabgrass quite high (over 90% after three applications, over 85% after two applications) but discoloration to the turf was negligible.

      2. The 10 g.p.a. rate gave a quicker response to both the crabgrass and the turf grasses, but ultimate control was not satisfactory.

      3. There were no observable differences in control between the 50 and 100 g.p.a. rates at the 8 pound level of treatment. Neither gave satisfactory control.

2. Series II - Gallonage constant (100 g.p.a.) - rate of chemical variable - 2-day intervals.

   The results of this series have shown a marked contrast to the results of the first series. While the interval of treatment in this series was extremely short, certain definite conclusions have been drawn.

a. The 16 lbs/A rate in three successive applications gave almost 100% control of crabgrass while 16 lbs/A in two successive applications gave 87% control. One application did not give satisfactory control. Discoloration of the permanent turf was noticeable at this rate but recovery was rapid (1-2 weeks).

b. The 8 lbs/A rate in three successive applications gave over 90% control. Discoloration to the turf was noticeably less than after three applications of the 16 pound rate. Two applications at the 8 lbs/A rate gave only 76% control with relatively less discoloration.

c. A single application at either the 8 or 16 lbs/A levels did not give satisfactory control under the conditions of this experiment.

D. DISCUSSION OF RESULTS

The most outstanding result of these experiments was the great difference between the two series of applications, not only in the degree of control of crabgrass but a lso in the extent of injury to the turf grasses, and the related rate of recovery. These differences are apparently due in part to the dissimilarity in weather conditions at the time of application as well as to the interval between applications.

Because of the prolonged drought and the very high temperature which prevailed during the first series of applications, the permanent turf grasses were nearly or quite dormant. The application of the higher rates of chemical (16 and 32 lbs/A) further weakened the turf to the extent that some died and that part which survived was very slow in recovering (4-6 weeks). This condition, contrasted to the improved growth conditions of the turf grasses in the later series of plots as brought about by cooler temperatures and increased rainfall, emphasizes the important role that weather conditions and timing of application play in the recovery of grass under treatment with this chemical. The higher moisture content which prevailed during the latter series favored a more active, succulent growth of the crabgrass, apparently making it more susceptable to the action of the contact herbicide. This observation agrees with studies by Watkins (3) in which growth of crabgrass has shown a positive correlation with moisture content of the soil.

Also contributing to the differences in these series of experiments is the number of successive applications. The latter series of tests definitely indicates that two applications give better control of crabgrass than one application and that three are best. Undoubtedly the two-day interval of treatment is extremely short from a practical standpoint, yet the results of the short-interval series demonstrated that under favorable weather conditions a wide safety margin exists for this material as exemplified by the application of 48 lbs/A of KOCN within six days without serious injury to the turf grasses.

E SUMMARY

1. Under the conditions of this experiment KOCN has given satisfactory control of crabgrass (*Digitaria sanguinalis*) at the rate of 8 and 16 lbs/A of actual chemical without causing permanent injury to the turf.

2. At least two applications of material on a given area are necessary to give satisfactory control of crabgrass.

3. Results of this experiment have shown that, in general, application of KOCN made during periods of hot dry weather are not as successful as applications made under more favorable growing conditions.

4. From these experiments it appears that the weather condition at the time of application is more important than the stage of growth of the crabgrass plants.

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Crabgrass Control with PMAS on Colonial Bent Putting-Green Turf and on Seedling Turf in Lawns.[1]

J. A. DeFrance and J. A. Simmons[2]

Tests reported in this paper were conducted at the Rhode Island Agricultural Experiment Station on (1) Rhode Island bent, *Agrostis tenuis*, putting-green turf for (a) prevention, and (b) for control of crabgrass; and (2) on seedling lawn turf for control of crabgrass. Tests were made on Colonial bent putting-green turf because the incidence of crabgrass has been noted to be more on it than on velvet or creeping bent. The seedling lawn turf which was mowed at a height of one inch consisted of individual plantings of Colonial, creeping, and velvet bent, and various mixtures of Kentucky bluegrass, creeping or Chewings red fescue and Colonial bent. The two turf areas contained two species of crabgrass, *Digitaria ischaemum* and *D. sanguinalis*.

Observations made during 1946 at the Rhode Island Agricultural Experiment Station and reported by DeFrance (1) indicated that certain water-soluble mercurial formulations appeared to be effective crabgrass controls. Reporting tests conducted during 1947 on several hundred plots of lawn turf with various mercurial formulations, sodium arsenite and 2,4-D preparations, DeFrance (2) stated that certain phenyl mercury preparations gave excellent control of crabgrass on lawns composed of Kentucky bluegrass, Chewings fescue and Colonial bent. Complete control of weeds, including common and fall dandelion, narrow and broad plantain, chickweed and crabgrass was obtained with a mixture of PMAS and 2,4-D butyl ester. Phenyl mercury formulations, such as PMAS and Puratized 641, also gave good control of some turf diseases, especially dollar spot. As a preventive against crabgrass and certain diseases in putting-green turf, it appeared advisable to apply the chemicals approximately once a month from June through September. Tests in 1948 reported by DeFrance (3) confirmed the 1947 observations by indicating that PMAS, a water solution of a phenyl mercury organic complex, gave excellent control of crabgrass at 1:5,000 actual toxicant in 10 gallons of water per 1,000 square feet. There was no permanent injury to basic turf grasses such as Kentucky bluegrass, Chewings fescue and Colonial bent. Comparable results were obtained when the same amount of toxicant was applied in less water, that is, 5, 2 or 1 gallon per 1,000 square feet. The volume of water may vary from 1 to 10 gallons, according to the type sprayer and provided sufficient is used for uniform coverage, but the amount of active materials applied to each 1,000 square feet must be constant. For maximum control with minimum number of applications, treatment should be made when the soil is moist, the temperature not excessive, and after the crabgrass seed has germinated, such as, late in July and August. The healthier the turf, the better the control will be, with less injury to the desirable grasses. Turf infested with weeds such as dandelions and plantain, in addition to crabgrass was freed of all such weeds by one application of a mixture of PMAS 1:6,000 and 2,4-D 1:4,000 active material in 10 gallons of water per 1,000 square feet,

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[1]Contribution No. 755 of the R. I. Agr. Exp. Station, Kingston, R. I.

[2]Agronomist and Graduate Assistant in Agronomy, respectively. The authors are grateful to Mr. C. H. Allen, Jr., Turf Foreman, for his interest in and assistance with the studies reported in this paper.

followed by two sprayings at weekly intervals with PMAS alone at 1:6,000. Reporting work conducted during 1948 by the New Jersey Agricultural Experiment Station, Engle and Wolf (4) indicated that certain phenyl mercury compounds were quite similar in their ability to control crabgrass and gave better control than sodium arsenite.

As a result of the mentioned foregoing tests, and the use of phenyl mercury preparations by several greenkeepers who reported excellent prevention and control of crabgrass in putting-greens, others became interested and requested more information. Furthermore, a typical question was asked by many: How would PMAS affect newly-planted lawn turf infested with crabgrass and could control of crabgrass be expected?

Materials and Methods

Based on results of previous tests with several different phenyl mercury compounds and other materials used for crabgrass control, it was decided to use a water solution of a phenyl mercury organic complex called PMAS (10%) manufactured by the W. A. Cleary Corporation, New Brunswick, New Jersey.

The following concentrations of PMAS (10%) were used:

A. On putting-green turf, applied at 10 gallons per 1,000 square feet: (1) 1:6,000 or 2.1 ounces, or 63 cc. (2) 1:8,000 or 1.6 ounces, or 47 cc. (3) 1:10,000 or 1.3 ounces or 38 cc.

B. On seedling turf, applied at 5 gallons per 1,000 square feet: 1:3,000 or 2.1 ounces or 63 cc.

The solution was applied with a Dobbins, 25-gallon power sprayer. For accuracy of application, the pump was calibrated to supply one gallon at 100 pounds pressure in 100 seconds.

Results and Discussion

Area 1: <u>A study of the prevention of crabgrass in Rhode Island Colonial bent putting-green turf cut at one-fourth inch height</u>. This area was known to contain considerable seed of both species of crabgrass. Individual plots were 100 square feet with each treatment replicated three times. Two concentrations were used: (1) 1:8,000 and (2) 1:10,000, and applied at 10 and 20-day intervals. Care was given to provide uniform coverage with the solution by spraying the plots twice over; the second time over was at right angles to the first. The spray nozzle was held two and one-half to three feet above the grass surface. Holding the nozzle very close to the turf did not allow adequate coverage and increased concentration that caused some discoloration. Applications began May 19 and were continued until August 6, 1949.

Results of the preventive study are presented in Table 1 where it can be noted that crabgrass could be prevented from growth throughout the season by applications of PMAS at concentrations of 1:8,000 and 1:10,000 every ten days. Untreated check plots had as high as 48 per cent crabgrass whereas none occurred on the treated plots. Applications at 20-day intervals provided 95 per cent control or better.

During this experiment applications were made on scheduled days regardless of temperature which ranged from 70° to slightly above 90°F. After the initial applications and applications made when the temperature was above 90°, slight discoloration was noted but lasted only a few days. No permanent injury to Colonial bent occurred, and it was observed that the treated plots appeared greener than the untreated plots throughout the season.

Treating turf throughout the summer with PMAS eliminated the crabgrass as it germinated or destroyed the crabgrass in the seedling stage.

Area 2: A study of the control of crabgrass with PMAS in Rhode Island Colonial bent putting-green turf cut at one-fourth inch height. Two concentrations were used: 1:6,000 and 1:8,000, applied at intervals of ten and twenty days. The first application was made June 28 when crabgrass was in the 3-leaf stage and it was quite evident that control measures should be taken. Treatments were continued until August 6 making a total of five treatments at ten-day intervals and three at twenty-day intervals. Again, no attempt was made to avoid application during periods of high temperature and treatments were made on regularly scheduled days. This gave opportunity to observe the maximum amount of turf discoloration from the two concentrations of PMAS that were considered stronger than the generally recommended rate for putting-green turf (1:10,000). After each treatment with the strongest (1:6,000) solution a discoloration of the turf was noted, but this did not last more than three days. The 1:8,000 concentration caused a slight discoloration which was not severe enough to be objectionable.

Results of the test are presented in Table II where it can be noted that the untreated plots were infested with 40 to 55 per cent crabgrass, whereas the plots treated at 10-day intervals with both the 1:6,000 and 1:8,000 concentrations were entirely free of crabgrass.

To further test a 1:10,000 concentration (1¼ ounces in 10 gallons of water per 1,000 square feet) on putting-green turf, a 500-square-foot section of Piper velvet bent was treated every 10 days, from June 18 to August 6. Complete prevention and control of crabgrass with no turf injury occurred from the five treatments that were applied, and furthermore, the treated turf appeared greener than the untreated.

Area 3: In order to test the effectiveness of PMAS for control of crabgrass in seedling lawn turf cut at one-inch height, a series of plots of individual grasses and mixtures were planted in late spring, May 14, 1949, in soil known to be infested with crabgrass seed. The area was 20 feet wide and 100 feet long. A 10-foot strip through the center of the area was used for treatment, thus leaving the outer half of each plot to serve as a check plot. Also, the 10 x 100 foot strip through the center made a total of 1,000 square feet to be treated and thus increased efficiency of operation.

By July 8, the date of the first treatment, the new turf was considered to be a month and one-half old which allowed 10 days from time of planting for

Table I – Results obtained on R. I. Colonial bent putting-green turf cut at one-fourth inch height using PMAS (10%) at two different concentrations at 10 and 20-day intervals to prevent infestation of crabgrass. Area 1. 1949.

Plot No.	Toxicant in water	Amount (cc. per 1000 sq. ft.)	Interval between applications	Per cent control after 3 applications at 20-day intervals and 5 applications at 10-day intervals[1]	Per cent control after 5 applications at 20-day intervals and 9 applications at 10-day intervals[2]
1	1:8000	47	10 days	100	100
2	1:8000	47	20 days	96	95
3	1:10,000	38	10 days	100	100
4	1:10,000	38	20 days	96	96
5	Check	—	—	(9)**	(22)
6*	1:10,000	38	20 days	96	92
7	1:10,000	38	10 days	99	99
8	Check	—	—	(14)	(48)
9	1:8000	47	10 days	100	100
10	1:8000	47	20 days	98	97
11	Check	—	—	(15)	(48)
12	1:8000	47	20 days	99	97
13	1:8000	47	10 days	100	100
14	1:10,000	38	20 days	97	95
15	1:10,000	38	10 days	100	100

* diseased area

**per cent crabgrass in check plots

[1] Notes taken June 30

[2] Notes taken September 26

Table III — Crabgrass control in Seedling Lawn Turf with PMAS[1]. 1949.

Plot	Rate of planting per 1000 sq. ft.	Individual grasses and per cent grasses in mixtures	Per Cent Crabgrass[2] Untreated Plots	Treated Plots	Per Cent Control
1A	2 lbs.	R. I. Colonial bent	2.0	0	100
1B	10 bu.	Arlington Creeping bent	3.0	0	100
2	2 lbs.	Astoria Colonial bent	4.5	0	100
3	3 lbs.	Creeping fescue 50 Kentucky bluegrass 35 Astoria Bent 15	18.0	Trace	99
4	4 lbs.	Astoria Bent 10 Kentucky B-27 40 Illahee fescue 50	48.0	1	98
5	3 lbs.	Astoria Bent 20 Kentucky Blue Comm. 80	67.0	2	97
6A	1 lb.	Piper Velvet bent	0.5	0	100
6B	2 lbs.	Seaside Creeping bent	1.0	0	100
7	2 lbs.	Highland Colonial bent	3.0	0	100
8	3 lbs.	Creeping fescue 70 Kentucky bluegrass 25 Astoria Bent 25	15.0	T	99
9	4 lbs.	Highland Colonial 10 Kentucky B-27 40 Illahee fescue 50	18.0	2	89
10	3 lbs.	Astoria Bent 20 Kentucky B-27 80	43.0	2	95

[1]1:3,000 (63 cc. or 2.1 ounces PMAS (10%) in 5 gallons per 1,000 sq. ft.) applied in three treatments: July 8, 18, and 28.

[2]Notes taken September 24.

Table II - Results obtained on R. I. Colonial bent putting-green turf cut at one-fourth inch height using PMAS (10%) at two different concentrations at 10 and 20-day intervals to control infestation of crabgrass. Area II. 1949.

Plot No.	Toxicant in water	Amount (cc. per 1000 sq. ft. in 10 gal. water	Interval in days between treatments	Per cent crabgrass before treatment[1]	Per cent crabgrass after treatment[2]	Per cent control after 3 applications at 20-day intervals and 5 applications at 10-day intervals
1	1:6000	63	10	18	0	100
2	1:6000	63	20	25	1	96
3	1:8000	47	10	24	0	100
4	1:8000	47	20	24	3	91
5	Check	—	—	29	55	0
6	1:8000	47	20	20	3	85
7	1:8000	47	10	26	0	100
8	Check	—	—	23	40	0
9	1:6000	63	10	30	0	100
10	1:6000	63	20	30	1	97
11	Check	—	—	20	45	0
12	1:6000	63	20	27	1	96
13	1:6000	63	10	27	0	100
14	1:8000	47	20	30	2	93
15	1:8000	47	10	31	0	100

[1]Notes taken June 28

[2]Notes taken September 26

germination or 55 days from time of seeding; the plots contained both species of crabgrass in the three-leaf stage. The concentration of PMAS used was 1:3,000 made by mixing 63 cc or 2.1 ounces of PMAS (10%) in 5 gallons of water for 1,000 square feet. Two more applications at 10-day intervals were made.

Table III shows the amount of crabgrass that developed on the various plots, and the control from the three applications of PMAS.

A comparatively small percentage of crabgrass developed on the area where the plots of individual grasses were planted. The range was from 0.5 per cent on Piper velvet to 4.5 per cent on the Astoria bent plot and 100 per cent control was obtained by treatment. There was a range of 15 to 67 per cent on the plots seeded with mixtures and control ranged from 89 to 99 per cent. Any crabgrass plants remaining in the treated plots were so retarded in growth that they failed to mature and set seed. No turf injury was observed from any of the three applications. In late September, approximately two months from the date of the last treatment, a severe attack of dollar spot occurred and damaged the untreated plots of Seaside and Arlington creeping bent, but no dollar spot was observed on the treated plots.

Summary and Conclusions

Results of the tests showed that PMAS applied on Colonial bent putting-green turf cut at one-fourth inch height effectively prevented and also controlled crabgrass.

Treatments started early in the season before crabgrass was noticeable gave 100 per cent prevention with concentrations of 1:8,000 (1.6 ounces) and 1:10,000 (1.3 ounces) of PMAS in 10 gallons of water per 1,000 square feet, applied at intervals of 10 days, and approximately 95 per cent control at 20-day intervals.

Another test conducted later in the season after crabgrass was in the three-leaf stage showed that 100 per cent control was obtained with applications of 1:6,000 (2.1 ounces) and 1:8,000 with 5 treatments at 10-day intervals.

Tests also showed that grass planted in the spring could be treated with a 1:3,000 concentration (2.1 ounces in 5 gallons of water per 1,000 square feet) the first season for effective control of crabgrass.

As in tests reported previously, in addition to the herbicidal properties of PMAS, fungicidal effects were observed indicating that the material is effective for the dual purpose of preventing and controlling crabgrass as well as certain diseases like dollar spot.

For practical purposes of crabgrass control 2½ ounces of 10% PMAS solution per 1,000 square feet is suggested for treatment of established lawn turf, 2 ounces for new lawn turf, and 1¼ ounces for putting-green turf. The type of sprayer and the amount of diluted solution employed, whether 1, 2, 5 or 10 gallons per 1,000 square feet should provide uniform coverage and distribution of the chemical.

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RESULTS OF TESTING CHEMICALS FOR CRABGRASS CONTROL IN 1949

Ralph E. Engel[1] and Dale E. Wolf[2]

The results of testing a number of phenyl mercury compounds, potassium cyanate and a series of experimental chemicals produced by the Sowa Chemical Company were reported in the Proceedings of the Northeastern Weed Control Conference of January, 1949. Additional tests were made with these materials in 1949. Two tests of 3 replications were started on July 27 and August 18, 1949, on a mixed turf that was predominantly Kentucky bluegrass. Plots were 4 x 15 feet in size. Application was made at a pressure of 40 pounds with a spray boom four feet long which was equipped with cone nozzles.

Estimations on the percentage of kill and the amount of turf injury were made by three individuals on September 24, 1949. Turf injury ratings were as follows: 0 - none; 1 - slight; 2- moderate; 3 - severe; and 4 - very severe.

Results of the first test are given in table I. The control obtained from the phenyl mercury compounds was more erratic than usual in this test. Control ranged from 0 for phenyl mercuric acetate solubilized to 62% control for C-Lect. In all cases the injury rating was slight or zero. The control obtained from using C-Lect at 5.5 gallons and 87 gallons of water per acre as compared to 4.5 gallons and 580 gallons of water increased the control from 10% to 62%. The use of 2,4-D with C-Lect improved the control of crabgrass from 62 to 85%, but resulted in an increase in the turf injury rating from a trace to an undesirable reading of 2.3.

The Sowa materials designated as S1840, S1861, S1980, and S1998 applied in three separate applications gave 96, 94, 83, and 93% control with injury ratings of 0.4 to 1.1. A single application of S1980 gave 83% control with an injury rating of 1.5. Two applications of potassium cyanate at 16 pounds per acre gave 79% control with an injury rating of 1.6.

Results of the second test are given in table II. The performances of the phenyl mercury compounds were consistently good with the exception of Dynacide. Also, the performances of S1840, S1861, S1980, and S1998 are slightly better than in Test I. Two treatments of potassium cyanate gave 99% control with an injury rating of 1.5.

Comparatively good control of crabgrass was obtained with TCA, CG-55, CG-101, and CG -102, but the injury ratings were rather unsatisfactory.

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[1]Research and Extension Associate, department of farm crops, Rutgers University - the state University of New Jersey - New Brunswick, New Jersey.

[2]Agent, U.S. Dept. of Agriculture, Division of Cereal Crops & Diseases, New Jersey Agricultural Experiment Station.

Table I. Control of crabgrass obtained by a series of chemicals applied on July 27, August 3, and August 9, 1949, New Brunswick, New Jersey.

Material	No. of applications	Rate of material per acre	Gallons of water per acre	Per cent Control of crabgrass	Turf Injury Rating
Sodium arsenite	3	2.7 lbs.	360	49	2.4
C-Lect (1)	3	5.5 gal.	87	62	0.1
C-Lect	3	4.5 gal.	566	10	0.
Phenyl mercuric acetate (Sol)(2)	3	0.71 gal.	566	0	0.
Puraturf crabgrass killer (3)	3	3.4 gal.	436	44	0.
Seltox (4)	3	4.09 gal.	436	47	0.
Dynacide (5)	3	43.5 lbs.	87	82	0.9
S-2000 (6)	3	0.84 gal.	566	15	0.1
C-Lect & 2,4-D (7)	3		87	85	2.3
S1840	3	25 lbs.	360	96	0.4
S1861	3	25 lbs.	360	94	1.1
S1980	1	9 gal.	360	83	1.6
S1980	3	4½ gal.	360	83	0.4
S1998	3	3 gal.	360	93	0.5
Potassium Cyanate *	2	16 lbs.	360	79	1.5

(1) A 1.75% phenyl mercuric acetate solubilized proparation of the Cleary Chemical Corporation and sold by the O. E. Linck Co.
(2) A 11.2% active phenyl mercury acetate solubilized preparation of the Gallowhur Chemical Corporation.
(3) A 3% phenyl mercury tri-ethanol ammonium lactate produced by the Gallowhur Chemical Corporation.
(4) A 2.3% phenyl mercury monoethanol ammonium acetate preparation sold by the Nott Manufacturing Co..
(5) Phenyl mercury acetate solubilized 1%, and phenyl mercury chloride 1% produced by the William M. Stieh Co., Inc.
(6) An experimental phenyl mercury solubilized supplied by the Sowa Chemical Company.
(7) C-Lect as in (1) with 1.8 gal. per acre of 8.2% triethanolamine salt of 2,4-Dichlorophenoxyacetic acid sold by O. E. Linck Co.
* 0.25% Vatsol K as a wetting agent.

Table II. Control of crabgrass obtained by a series of chemicals applied on August 18, August 25, and September 2, 1949. New Brunswick, New Jersey.

Material	No. of applications	Rate of material per acre	Gallons of water per acre	Percent Control of crabgrass	Injury Rating
Sodium arsenite	3	2.7 lbs.	360	74	2.7
Mercuric chloride	3	13.56 lbs.	360	43	0.1
C-Lect	3	5.4 gal.	87	91	1.0
C-Lect	3	4.5 gal.	566	84	0.1
Phenyl mercuric acetate (Sol.)	3	0.71 gal.	566	80	0.1
Puraturf crabgrass killer	3	3.4 gal.	436	83	0.1
Seltox	3	4.09 gal.	436	85	0.4
Dynacide (1)	3	11.8 lbs.	87	47	0.1
S-2000	3	0.84 gal.	566	88	0.1
PMAS (2)	3	1.17 gal.	360	86	0.7
S1840	1	75 lbs.		86	1.5
S1840	2	40 lbs.	360	98	1.9
S1861	1	100 lbs.		91	2.1
S1861	3	25 lbs.	360	95	0.5
S1980	1	9 gal.		67	0.1
S1980	3	3 gal.	360	90	0.5
S1998	1	12 gal.		83	2.0
S1998	3	4½ gal.	360	97	1.8
Potassium Cyanate*	2	16 lbs.	360	99	1.5
Tri-chloro acetate *	2	12 lbs.	360	89	4.0
CG-55 (3)	3	6.9 gal.	360	88	2.1
CG-101 (3)	3	435 gal.	0	94	2.5
CG-102 (3)	3	435 gal.	0	94	3.2

(1) A preparation of 5% phenyl mercury chloride and 5% phenyl mercury acetate solbuilized.
(2) A 10% solution of phenyl mercuric ion computed as phenyl mercuric acetate, of the Cleary Chemical Corporation.
* 0.25% Vatsol K.
(3) The CG series are experimental herbicides produced by the Esso Laboratories.

The results of treating unreplicated plots of V-410*, V-411*, and monosodium cyanamide on August 24, September 3, and September 7 are given in table III. The control of crabgrass was 93, 99, and 98 percent respectively. These values compare very favorably with the check plots of C-Lect and Puraturf Crabgrass Killer that gave 94 and 96 percent control, respectively. Also, the experimental materials compared favorably with the mercury treatments with regard to turf injury.

Table III. Percent control of crabgrass and degree of injury obtained with some experimental chemicals on unreplicated trial plots** New Brunswick, New Jersey.

Material	No. of applications	Rate of material per acre	Gallons of water applied per/A	Percent control of crabgrass	Turf injury
C-Lect	3	5.4 gal.	87	94	1.7
Puraturf Crabgrass Killer	3	6.8 gal.	436	96	1.3
V-410	3	30 lbs.	360	93	1.7
V-411	2	30 lbs.	360	99	0.7
Monosodium cyanamide***	3	20 lbs.	360	98	1.3

**Applications were made on August 24, September 3, and Sept. 7,1949.
*** 0.25% Vatsol K

SUMMARY OF RESULTS

The phenyl mercury compounds were more erratic in the 1949 season. Higher concentrations were required during the dry weather of July and early August. As in 1948 the phenyl mercury compounds tested again show a marked similarity in ability to control crabgrass with a minimum of turf injury.

Results obtained with S1840, S1861, S1980, and S1988 were better than for the 1948 season. As compared to the phenyl mercury treatments, they gave more consistent and somewhat better control of crabgrass. However, they inflicted more turf discoloration and injury. The use of multiple treatments gave the best results.

The results obtained with potassium cyanate were equally as good or better than those obtained in the 1948 season. More injury was produced than with the phenyl mercury treatments but the control ratings were higher.

The control of crabgrass obtained from the plots of trichloro acetate, CG-55, CG-101, and CG-102 was good. However, the injury ratings tended to be higher than is desired.

The trial plots of V-410, V-411, and monosodium cyanamide gave very good control. Also, the slight to moderate injury ratings show that these materials are very worthy of additional study.

*Materials V-410 and V-411 are experimental products supplied by the Mallinckrodt Chemical Works, St. Louis, Missouri.

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ABSTRACT

CONTROL OF WEEDS IN DENT CORN BY THE USE OF 2,4-D TREATMENTS

By
L. E. Hogue and R. G. Rothgeb
Agronomy Department, University of Maryland Agr. Exp. Station

A weed control project of the farm survey type was started in 1949. Objectives were (1) to study time of application, (2) to determine the effect of using one or more cultivations in conjunction with chemical control, and (3) to estimate the usefulness of 2,4-D in control of corn-field weeds in Maryland.

Data were collected from 24 corn fields in 12 counties extending from the Limestone Valley on the west through the Coastal Plain on the east. Only two fields had light soils. Other than the stage of crop growth and the willingness of the farmer to cooperate, no special choice was exercised in selecting the fields. With three exceptions post-emergence application went on when corn was from ½ to 4 inches tall. Pre-emergence applications varied from 1 day after planting until emergence. For the convenience of the farm cooperator, test design was simple and the number of treatments were limited. Individual treatment plots were 4 rows wide and 50 ft. long and each was duplicated. Some fields received the set of post-emergence treatments and others the set of pre-emergence treatments. Post-emergence treatments were as follows: (1) Regular farm cultivation; (2) ½ lb. per acre 2,4-D, no cultivation; (3) ½ lb. 2,4-D per acre and the last cultivation; (4) 1 lb. 2,4-D per acre, no cultivation. Treatments 5, 6 and 7 consisted of two applications separated by a period of 2 to 3 weeks for treatments 2, 3 and 4 respectively.

With the exception that the rate of application for 2,4-D was doubled in each case, pre-emergence treatments were the same as for post-emergence treatments. Treatments 5, 6 and 7 had a pre-emergence treatment at double rate followed by a post-emergence application at the rates given above.

The amine form of 2,4-D was used throughout. Application was made by means of a specially constructed push-type rig mounted on bicycle wheels. Pressure was supplied by compressed air. Distribution was made through 4 T-jet nozzles at a pressure of 15 lbs. per sq. in. and calibrated to put on 8 gallons of solution per acre.

In general weed control was good; however, dry weather following initial treatments may have influenced results. Counts about 6 weeks after the initial applications and figured in terms of the no-treatment check showed a range for grasses from 58% control on plots treated once (post-emergence) with no cultivation to 81% control on plots treated once (pre-emergence) with one cultivation. Control of broadleaf weeds varied considerably. A low of 31% control was obtained for one post-emergence treatment and no cultivation, while a high of 91% control was obtained for one pre-emergence treatment with a follow-up post-emergence treatment with one cultivation. Pre-emergence treatment with or without cultivation gave better control of broad leaved weeds than did post-emergence treatment. Regardless of cultivation and time of application two applications were superior to

one application. The 1 lb. post emergence application gave better control than the $\frac{1}{2}$ lb. rate. One cultivation increased control for both types of weeds.

Yields from 10 farms were obtained. Plots treated once and with one cultivation, and plots treated twice and with one cultivation did not differ significantly from all-cultivation plots. Regardless of chemical treatment all non-cultivated plots were significantly lower in yield than corresponding plots with cultivation. Apparently cultivation contributed something in addition to weed control.

In general it seems safe to conclude that chemical weed control was of practical value and that one or possibly two cultivations might be eliminated by its use. Further work is needed for confirmation.

Recent Developments in Chemical Brush Control

L. L. Coulter[1]

The commercial use of various chemicals for the control of woody plants has reached the point where chemical brush control, in itself, can no longer be regarded as a new development. There are, however, many phases of this problem which may be regarded as new and which are still under investigation.

One particular weak point in our chemical brush control program is the fact that we are not able to carry out a 12 month spraying schedule. While countless miles of right-of-way are sprayed during the brief summer months this operation comes to an abrupt halt with the approach of frost and can not be resumed until vegetation is in full leaf some eight or nine months later. Large groups of power equipment are tied up for this entire period and management must find other duties for their well trained crews. Furthermore, dormant season spraying can be carried out with relative safety in areas where during the summer months, risk of injury to sensitive annual crops is too great. Experimental work concerned with the control of stumps during the dormant season was initiated in 1946 and has gradually expanded into the field of standing brush control. This stump work demonstrated conclusively that control of stumps, with growth substance herbicides, is possible during any season of the year provided that the proper carrier and concentration were employed. With this background experimental work on dormant brush has continued with a gratifying degree of success.

The fundamental difference between dormant and foliage treatments lies in the fact that we do not have any active growing leaves to intercept, absorb and possibly assist in translocation of the herbicide. While unquestionably some material is absorbed by immature stems in foliage applications, the primary source of entrance into the plant appears to be through the leaves. In dormant applications a carrier must be used which will actually carry the esters through the relatively impermeable bark. Experimental work has shown that such oils as fuel oil and kerosene are particularly effective for this purpose. Emulsions of 2,4-D or 2,4,5-T have been effective in isolated instances but are not dependable, however, they may have some possibilities when additional oil is added to the emulsion. At the present time fuel oil or kerosene alone appear to be our most reliable carriers.

It is of considerable interest to note that in 2,4,5-T we have a herbicide which appears to be particularly adapted to dormant applications - irrespective of the species treated. Current research does not accurately establish the relative effect-

1. Agronomist - The Dow Chemical Co., South Haven, Michigan

iveness of 2,4-D and 2,4,5-T, however, the latter has been consistently more effective. In one particular experiment where 2,4,5-T was applied at a concentration of 8000 ppm in fuel oil the brush failed to produce leaves the following summer. In contrast where a mixture containing 4000 ppm of each 2,4-D and 2,4,5-T, or a total of 8000 ppm, the brush leaved out slowly and leaves began to die during mid-summer. Finally, where 8000 ppm of 2,4-D was applied only formative effects were noted on the leaves of such species as oaks, maple, cherry, etc. while an occasional plant was killed. This concentration (8000 ppm) of 2,4,5-T produced results comparable to one standard commercial foliage treatment. Higher concentrations of 2,4,5-T did not appear to be any more effective than the 8000 ppm concentration. On the other hand it was necessary to double the concentration of the mixture containing equal parts of 2,4-D and 2,4,5-T to obtain equivalent results, thus indicating the dominant role of 2,4,5-T.

Applications have been made as an overall spray and as base sprays (from the ground up to 2 ft. high). These have shown a slight but not practical advantage in favor of the overall treatment. It is evident that on short brush, four ft. or less tall, an overall spray will be most satisfactory, while on taller brush the base spray is most efficient when cost of materials and time is considered. In either instance complete coverage of the stems at and near the ground line is a primary essential. This base spray treatment at somewhat higher concentrations has also given good results on standing trees. Concentrations of 30,000 to 40,000 ppm in a narrow band at the base of trees as large as 20 inches in diameter have given good control.

Dormant treatment of brush lends itself very well to knapsack treatment. These sprayers can apply material with a minimum of waste. When dealing with a relatively more expensive spray as we are in dormant work this may be very important. Standard weed nozzles such as Spraying Systems 8004 are very satisfactory while 6504 nozzles will provide a smaller spray pattern and may be more efficient on smaller brush. The full-jet No. 1 nozzle which provides a narrow solid cone spray is very satisfactory for stump spraying. During the dormant period when brush is not in full leaf rapid progress can be made in covering right-of-way with a knapsack sprayer.

The entire concept of dormant spraying for brush control is still in its infancy and many phases such as methods of application, concentration, effect of temperature, and time of application are still problems for intensive research. However, at this point it is evident that under most conditions 8000 ppm of 2,4,5-T in fuel oil, if carefully applied, will control dormant brush.

During the early developmental stages of 2,4-D extensive research failed to demonstrate any greatly significant differences in the activity of the various lower alkyl esters. However, recent experimental work has demonstrated a wide range of activity among some of the higher esters of 2,4-D and 2,4,5-T. Certain of these esters have proven to have greater activity on woody plants and have been available to many of you for experimental work this year. These new esters are particularly effective on such resistant species as ash and promise to be an important addition to the chemical brush control program.

Some interesting results have been obtained by a rancher in Missouri using a "swab" technique on two year old oak brush. The equipment for this operation is simply a gallon can with a gravity feed through a tube to a cellulose sponge. With this simple device plants are swabbed quickly and effectively at the base with a concentrate solution containing 1/2 lb. of 2,4-D and 1/2 lb. of 2,4,5-T per gallon. Results have been very good with this treatment and chemical cost has been exceptionally low.

In connection with new developments in brush control it may be of interest to many to note the recent progress which has been made in the control of brush on range land.

At Spur, Texas, C. E. Fisher has done some very extensive and carefully planned work on the eradication of mesquite from the range lands of that area. This year airplane applications of 2,4,5-T have given outstanding control of top growth and, as indicated by inspection of the roots and bud zone, have given extremely good control of the entire plant. These tests demonstrate rather clearly the importance of 2,4,5-T or mixtures of 2,4,5-T and 2,4-D. Fisher believes, and his ideas have been verified in other sections of the country, that 2,4,5-T acts more consistently and is less subject to the influence of environmental conditions than is 2,4-D or the mixtures of the two. It is interesting to note that the aerial applications made during May of this year appear to be more effective than hand applications made at the same time. While apparently satisfactory results have been obtained with as little as 1/3 lb. of 2,4,5-T per acre it is probable that at least 2/3 lb. will prove to be most satisfactory over a wider range of conditions. Best results have been obtained during mid-May or early June.

Many potential grazing areas in the cross-timbered area of Oklahoma are either completely taken over by this relatively useless timber or have been reduced to the category of woodland pastures with a very low grazing capacity. Various agencies particularly the Red Plains Soil Conservation Experiment Station have studied this problem from the standpoint of brush eradication and its effect on the subsequent growth of grasses and the grazing capacity of the range. Their work, which has been carried out primarily by H. E. Elwell, has demonstrated conclusively, that these wooded areas can be restored to the condition of good pasture.

Extensive field testing this year, particularly by commercial companies, has shown us the possibilities that exist in the way of chemical control of this brush. In several typical areas, the leaves of large oak trees have been completely killed by one application of a commercial mixture of 2,4-D - 2,4,5-T (brush killer) Examination the latter part of this year indicates that a very good top kill has been obtained while evaluations of root-kill have to be made next year. In aerial applications of experimental materials made last year at least 80 per cent kill has been obtained and native grasses are thriving. Big and little bluestem have covered some of the 1948 plots near Bartlesville, Oklahoma and have grown higher than a man's head in many instances.

Our conception of what constitutes satisfactory control may have to undergo some adjustment for these problems. In the cross-timbered area 80 per cent has been established as a successful commercial control. This amount is sufficient to release virtually the entire range for grasses since those trees, not actually killed in an application with this degree of success, frequently only produce a few leaves which do not interfere materially with grass production. In the mesquite area top kill for a year is worth a great deal in terms of grass development and in the fact that the successful rounding up of livestock can be accomplished whereas this is extremely difficult in areas where a dense cover of mesquite exists. In this instance perhaps some slow regrowth could be tolerated if respraying was not necessary for two or more years. This, of course, is a compromise and certainly not the objective of the research worker. In the final analysis the test of effectiveness is measured in terms of additional beef produced. These two range problems are in the advanced stage of experimental development and have come to the point where reasonable suggestions can be made for extensive field trials. We do not have, however, enough information to warrant an unqualified recommendation for indiscriminate spraying of mesquite or brush in the cross-timbers areas. One of the major keys to the success of this problem is the proper method of application. Unquestionably the practical method is by airplane but we should attempt to obtain more information on the effect of droplet size, carrier, altitude, etc. In the cross-timbered area where we are dealing with extremely dense foliage and large trees predominantly oak, the relative merits of 2 applications applied across each other or applied several weeks apart should be carefully investigated.

Within recent years considerable progress has been made in the field of chemical brush control. New developments in chemicals and methods of their application have come rapidly and chemical brush control is now an accepted commercial practice. The commercial acceptance of this control program and the recent developments certainly contribute to a general feeling of optimism about the entire field of chemical brush control.

Results of Preliminary Tests in Highway Weed Control Work in Tompkins County [2]

P. B. Kaufman and A. M. S. Pridham[1]

The use of 2,4-D as an herbicide for the control of lawn weeds proved successful in tests made in 1946 and 1947. Limited applications were made along local roadsides. The results were encouraging so that in 1948 with the cooperation of the Tompkins County Highway Department field tests were undertaken.

The following procedure was used: (a) a preliminary weed survey was made, (b) plots were selected on the basis of type and population of weeds. The plots having the common herbaceous weeds in large populations with at least 1 plant per square foot throughout the area of the plot were designated for herbaceous weed control treatments. (c) Plots having common woody weeds in similar large populations were designated for woody weed control treatments. (d) Posts with numbers on them existed at 0.2 mile intervals along the roadside and these were chosen to mark the plots to be treated. (e) A plot lay between 4 posts, thus having a length of 0.6 miles and a width of 5 feet.

The tractor borne apparatus used in the 1948 experiments is described in detail in another publication (1). In 1949 spray equipment consisted of 3 gallon knapsack sprayers fitted with "Spraying System" off center type nozzle, giving a coarse spray 5 feet wide. The weather conditions encountered during the spray operation of 1948 and 1949 are indicated in Table I.

TABLE I

* Temperature and Wind Velocity Data on Spraying Dates

Date	Temperature (degrees F.)			Wind Velocity (miles per hour)		
	Maximum	Minimum	Mean	7-9:00 A.M.	12:00 Noon	3-4:00 P.M.
6/14/48	77	45	61	S. 4.0	S.W. 3.3	S.W. 6.0
6/17/48	72	40	56	S.W. 1.3	N.W. 4.0	N.W. 8.3
6/18/48	75	41	58	S.E. 2.0	N.W. 2.7	N. 1.3
7/15/48	82	48	65	N.E. 0.7	N. 1.3	N.W. 3.0
7/16/48	81	56	68	S. 4.3	S.E. 12.7	S.E. 7.3
7/20/48	85	54	70	S.E. 1.7	S.W. 2.0	S.W. 4.3
8/20/48	80	54	67	S.W. 0.7	N.W. 3.3	N.W. 4.3
3/30/49	46	36	41	N.W. 6.3"	N.W. 6.3	N.W. 7.0
3/31/49	36	32	34	N. 1.3	N.E. 6.3	N.E. 8.7
4/30/49	79	42	60	S.E. 4.3	S.E. 2.4	- - -

* Secured from Dr. R. A. Mordoff of Cornell University (Dept. of Meteorology).

[1]Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, N. Y.

[2]These tests conducted in cooperation with the Tompkins County Highway Department.

TABLE II

The spray program for 1948, the quantities of 2,4-D (amine) used, the number and date of applications made, and the number of plots treated.

lbs./2,4-D Acre/Treat.	Number of plots receiving 1, 2 or 3 treatments		
	Single 6/15	Two 6/15, 7/15	Three 6/15, 7/15, 8/20
1.6	6	4	5
3.2	2	2	2
4.8	2	1	2

The results of the spraying are summarized in Table III, which gives the estimated reduction in stand of weeds in June 1949, essentially a year following the date of the first application of 2,4-D. Estimates are based on records taken in 1948 and also in June 1949 by direct comparison with control plots in adjacent areas.

Weeds for which maximum control was obtained without repeated applications of 2,4-D include the following plants: Achillea Millefolium, Aster sp., Barbarea vulgaris, Daucus Carota, Equisetum arvense, Heiracium aurantiacum, Heiracium pratense, Plantago lanceolata, Plantago major and Taraxacum officinale.

Weeds for which best control was obtained when treatments were repeated or by large amounts of 2,4-D in a single treatment include such plants as Asclepias syriaca, Chrysanthemum Leucanthemum var. pinnatifidum, Onoclea sensibilis, Pastinaca sativa, Ranunculus acris, Rumex sp., Salix sp., Sedum triphyllum, Solidago sp. and Ulmus americana.

Relatively poor control of weeds in mid-June treatment may be ascribed to incomplete and unsatisfactory coverage due to the tall grass growing along the highway at that time. This grass shelters the weeds, particularly seedling weeds, so that the results compared with those obtained on close cut lawns appear to be entirely unsatisfactory. Increasing the volume of spray mixture applied or increasing the pressure under which the spray mixture is applied may be necessary to increase the efficiency of 2,4-D as a weed killer under highway conditions. In July and again in August the volume of spray was increased from 5 to 15 gallons per acre.

Winter Applications to Woody Weeds

Winter weed control of woody plant materials was undertaken during January 1949 and in a second experiment in March and April 1949. The chemicals used in this work included 2,4-D triethanolamine salt, 40% 2,4-D ethyl ester formulation, 2,4,5-T isopropyl ester formulation (Esteron 44). These were diluted with diesel oil, equal parts by volume, to get a 50 percent mixture and in other cases a 5 percent mixture by increasing the amount of oil proportionately. The oils used included diesel oil (March) and in April Socony Vacuum Company oil 975A.

Table III
Estimated reduction in stand expressed in percent.

Herbaceous Weeds	Estimated reduction in stand expressed in percent								
	1.6 pounds per acre			3.2 pounds per acre			4.8 pounds per acre		
	Single	Two	Three	Single	Two	Three	Single	Two	Three
Achillea Millefolium	7	50	90	80	95	95	-	-	-
Arctium Lappa	7	50	50	-	-	-	-	-	-
Asclepias syriaca	0	-	0	0	25	-	0	50	75
Aster novae-angliae spp.	5	5	50	50	60	-	-	-	-
Barbarea vulgaris	95	100	100	100	-	-	100	-	-
Chrysanthemum Leucanthemum var. pinnatifidum	-	7	-	35	-	-	65	-	-
Daucus Carota	50	80	95	50	-	-	-	-	-
Equisetum arvense	35	50	95	50	75	-	-	-	-
Fragaria vesca var. americana	0	-	-	0	-	0	-	-	-
Hemerocallis sp.	0	-	-	0	-	-	-	-	10
Hieracium pratense) " aurantiacum(	-	50	100	100	100	-	-	-	-
Lactuca Scariola	-	95	-	-	-	-	-	-	-
Onoclea sensibilis	-	-	50	-	75	90	33	66	-
Pastinaca sativa	10	10	-	50	75	-	-	80	-
Plantago lanceolata) Plantago major (	5	75	95	-	-	-	-	-	-
Ranunculus acris	25	50	-	25	50	-	-	-	100
Rumex crispus (" obtusifolius)	10	10	60	15	-	90	0	-	-
Sedum triphyllum	-	-	5	-	-	-	-	-	100
Solidago sp.	-	25	-	20	50	75	50	65	75
Sonchus arvensis	0	80	95	-	-	-	-	-	-
Taraxacum officinale	25	85	95	-	-	-	-	-	-
Typha angustifolia	-	0	0	0	-	-	-	-	-
Vinca minor	-	-	0	-	-	-	-	-	-
Viola spp.	-	-	0	-	-	-	-	-	-

Table III (Continued)
Estimated reduction in stand expressed in percent.

Woody Weeds	Estimated reduction in stand expressed in percent								
	1.6 pounds per acre			3.2 pounds per acre			4.8 pounds per acre		
	Single	Two	Three	Single	Two	Three	Single	Two	Three
Acer saccharum	-	-	0	-	-	5	-	-	25
Cornus Amomum) " stolonifera(	-	-	0	-	0	-	-	0	-
Fraxinus americana	-	-	0	-	-	0	0	-	-
Prunus virginiana	5	-	-	25	50	-	30	5	10
Rhus Toxicodendron	50	-	-	-	-	-	-	-	-
Rhus typhina	-	-	-	-	-	-	25	-	-
Rubus	-	-	-	-	0	0	-	-	0
Salix spp.	-	10	50	95	-	100	-	-	-
Ulmus americana	-	-	-	50	50	75	-	-	80

Winter Application to Woody Weeds (Continued)

Experiment 1

Treatment of tall brush was made in January. Twelve samples of 20 plants each in sizes of 1 to 3 inch trunk diameter were selected among the following species for treatment: Acer saccharum, Fraxinus americana, Prunus serotina, Prunus virginiana, and Rhus typhina. Twenty plants were selected for each chemical and each concentration applied. Five of the 20 trees were left with the bark uninjured, 5 had the bark frilled in a complete ring, 5 with the bark slashed and 5 plants with the tops cut out and the chemical applied to the cut surface. Chemicals were applied to a band approximately 1 inch wide to completely girdle the trunk or cover the wound surface. Observations were taken in October 1949, approximately 9 months after date of treatment.

Experiment 2

Mixed stands of cut over brush along the roadside were treated in March and April. These stands contained a large percentage of chokecherry and a variety of other woody species. Brush had been cut over during the month of February by the highway department. Stubs from 4 to 6 inches in length remained for treatment. Plots were laid out 50 feet long and 5 feet wide. One quart of spray mixture was applied to this area by means of a knapsack sprayer. Estimates of control were taken a month after treatment. In October 3 samples of 3 square feet each were marked out and all brush and herbage removed from these areas. Counts were made of live and dead brush and dry weights taken of the herbage. The results are given in Tables V and VI.

Table IV

Mortality (%) of plant tops at end of one growing season following winter treatment.

Chemical Treatment*	Plant Species	Trunk Whole	Trunk Frilled	Trunk Slashed	Trunk Topped
2,4-D Amine	Acer saccharum	0.0	9.0	6.0	0.0
	Fraxinus americana	0.0	33.0	0.0	6.6
	Prunus virginiana	0.0	20.0	6.6	40.0
	Rhus typhina	66.0	73.2	26.6	63.9
2,4-D Ester	Acer saccharum	0.0	21.3	6.2	0.0
	Fraxinus americana	6.6	45.0	7.7	6.6
	Prunus virginiana	7.7	36.5	12.0	0.0
	Rhus typhina	73.2	60.0	26.6	52.6
2,4,5-T	Acer saccharum	7.7	30.8	13.0	0.0
	Fraxinus americana	14.0	40.0	35.5	7.7
	Prunus virginiana	0.0	0.0	10.0	0.0
	Rhus typhina	66.6	73.2	23.1	13.2
Oil	Acer saccharum	0.0	0.0	0.0	0.0
	Fraxinus americana	0.0	0.0	0.0	0.0
	Prunus virginiana	0.0	0.0	0.0	0.0
	Rhus typhina	0.0	0.0	0.0	0.0

* Oil mixtures used were 50% growth regulator and 50% Socony Vacuum 975A oil. Chemicals applied to the trunk were effective in Rhus typhina. Otherwise chemical treatment was most effective when combined with frilling or ringing the trunk. Ester formulations appear to be more effective than the amine. 2,4,5-T is equally effective with 2,4-D ester formulations used.

Table V

Mortality (%) of cut over brush based on counts taken in October following treatments in March using 1 pint commercial concentrate to 250 square feet plot of Prunus virginiana, Prunus serotina, Cornus paniculata population. 1.34 plant sq. foot.

2,4-D oil Mixture		2,4,5-T oil Mixture	Oil Alone
Amine	Ester	Ester	
100.00	68.75	57.89	26.09
50.00	75.00	87.50	25.00
85.72	95.00	75.00	-
76.00	73.91	94.76	-
Mean 77.93	78.16	78.78	25.54

All treatments differ at 1% level from the control (oil) but do not differ significantly one from another. Untreated cut over brush showed 4.55% mortality.

Table VI

Mortality in percent of cut over brush based on counts taken in October following April treatments using 1 pint of commercial concentrate to 250 square feet plot of Prunus virginiana, Prunus serotina, Cornus paniculata population. 1.07 plant /sq. ft.

	2,4-D oil Mixture	2,4,5-T oil Mixture	Oil Alone
	Amine	Isopropyl Ester	
	40.00	50.00	21.42
	37.50	75.00	21.42
	40.00	85.71	9.09
	80.00	57.14	46.15
Mean	49.37	66.96	24.52

Only 2,4,5-T differs at 1% level from the control (oil) treatment. Untreated cut over brush showed 4.55% mortality.

It will be seen from Table V that the use of oil increases the mortality of the brush over untreated brush and that there is a statistically significant difference between the use of the growth regulators in an oil mixture over the oil alone. There was no statistically valid difference between the 2,4-D and 2,4,5-T in these tests.

As indicated in Table VI, only the 2,4,5-T differed from the oil in April. Comparing the mortality in March with that in April, no significant difference was found between the two dates of application. The average mortality is consistently higher in March treatments than in April. Hence, there would seem to be no reason for delaying the application of the herbicide until bud break in the spring.

Table VII

The effect of winter application of herbicide on the growth of grass and herbaceous plants. Results are stated as average dry weight in grams from 3 samples 3 sq. feet. Treatments were made in March. Observations were taken in October.

	2,4-D oil Mixture		2,4,5-T oil Mixture	Oil Alone
	Amine	Ester	Isopropyl Ester	
	18.5	17.7	7.2	9.7
	12.2	7.1	6.0	10.3
	30.6	37.3	11.1	38.4
	34.9	61.5	0.0	13.1
Mean Weight	24.05	30.90	6.07	17.87

Average of 2 untreated plots 65.80 grams. None of the treatments differ statistically at the 1% level. 2,4,5-T does differ statistically from 2,4-D ester formulation at the 5% level. In comparing March and April treatments, a statistical difference exists only in the case of 2,4,5-T plots.

Table VIII

The effect of winter application of herbicide on the growth of grass and of herbaceous plants. Results are stated as average dry weight in grams from 3 samples each 3 sq. ft. Treatments were made in April. Observations were taken in October.

2,4-D oil Mixture	2,4,5-T oil Mixture	Oil Alone
Amine	Isopropyl Ester	
53.7	20.2	65.9
17.5	18.9	20.0
11.6	7.3	21.6
5.6	20.5	13.6
Mean Weight 22.1	16.7	30.3

Average dry weight of 2 untreated plots 65.80. None of the plots show statistical differences at either 1% or 5% level.

SUMMARY

1. Low volume-low pressure applications of herbicides along roadsides is less successful than similar applications made in lawn areas to control the same weed species.

2. Many weed species can be controlled along roadsides by using 2,4-D in repeated applications or at higher rates per acre.

3. Tall growing species controlled by 2,4-D in these tests include: Achillea Millefolium, Aster novae-angliae sp., Barbarea vulgaris, Daucus Carota, Equisetum arvense, Onoclea sensibilis, Rumex sp., Solidago sp., Sonchus arvensis, Salix spp.

4. Tall weeds poorly controlled by 2,4-D under highway conditions in these tests include: (a) herbaceous - Asclepias syriaca, Chrysanthemum Leucanthemum var. pinnatifidum, Typha angustifolia; (b) woody - Acer saccharum, Cornus Amomum, Cornus Stolonifera, Fraxinus americana, Prunus virginiana, Rubus sp.

5. Winter spraying of woody species in these tests gave little control unless the herbicide was applied to a cut surface. For killing trees, ringing the trunk appears desirable. For treating cut over brush, spraying the stubble with large amounts of growth regulator reduces resprouting. Treatment is no more effective after bud break than dormant treatment before bud break.

6. Winter spraying needs further testing to determine minimum dosages and many other points of practical importance for control of herbaceous and woody weeds.

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Control of Black Locust with Chemical Sprays

W. C. Bramble and D. P. Worley[1]

Although black locust is ordinarily a desirable tree on farms, it occasionally becomes a weed species that must be controlled. In such cases, owing to its tenacious sprouting and root-suckering ability, the species is difficult to eradicate by simple cutting procedures. Use of the chemical sprays has been suggested as a promising method which may be substituted for repeated cutting. Although we have reports available which show susceptibility of locust to various sprays, we have not known just what it takes to eradicate the species as a weed tree. For example, certain important features of an efficient eradication program such as number of times an area must be resprayed and the cost of repeated spraying should be worked out before making concrete recommendations to land owners.

The tests reported in this paper were carried out on an old field where locust, 6 to 8 inches in diameter, had been cut and had given rise to a dense thicket of suckers that had reached a height of 10 to 15 feet. As the owner desired to clear the field of locust, the first tests were designed to accomplish this task by certain recommended techniques with a view to determining the length and expense of an eradication program. Later, more tests were added to try out additional chemicals and techniques.

In a first test undertaken in 1947, 10 to 15 foot locust sprouts on a portion of the field were sprayed in late summer with Ammate (35 per cent solution of 80% ammonium sulphamate) without previous cutting. This resulted in but a partial kill of the trees and encouraged abundant suckering and sprouting. Although a second and third foliage sprays have been given to this area, sprouts are still abundant.

Two duplicate randomized blocks were laid out in a second part of the field the following spring. These were designed to compare 2,4-D sprays with ammonium sulphamate, both to be applied in solution using a common knapsack, garden-sprayer. The locusts on these blocks were cut back to about 8 inches above the ground in June 1948, a tall stub being necessary to prevent coverage by grass and weeds. The freshly cut stubs were then treated by wetting them thoroughly with a moderately coarse spray of the chemical to be tested; at the same time a general spray was given to each test area to reduce other weed growth and to avoid missing locust stubs. The chemicals used were Ammate (ammonium sulphamate) in a 30% solution and Esteron 44 (2,4-D isopropyl ester) in a 10% water solution and in a 2½% oil solution.

The stub sprays resulted in approximately a 60 per cent kill of original stubs with all chemicals. However, abundant new sprouting and suckering followed the Ammate spray so that the summer after spraying there were about 2½ times more stems present than before spraying. Esteron 44 both in oil

1 Professor and Instructor, respectively, Forestry Department, The Pennsylvania State College.

and in water greatly reduced not only the original stubs but also the number of stems per acre by about one-half. With all chemicals, however, there were still too many sprouts and suckers by midsummer to give adequate control. One-half of each plot was therefore given a foliage spray of the same chemicals in August, 1948, when the new sprouts were about 3 feet tall. A 30% solution of Ammate was used to compare with a 0.4% and a 1.0% water solution of Esteron 44.

Both foliage sprays given in the second application were very effective in reducing locust to a point where very little additional control spraying was necessary. Ammate reduced the number of stems 92%; Esteron 44 in water reduced the stems 93% and Esteron in oil 39%. A second foliage spray was given to each plot in August, 1949, to take care of scattered sprout groups which had arisen since the August, 1948, spray. This spray was in the nature of a clean-up which cleared the field completely of living locust stems. It is expected that permanent exclusion of locust will be impossible owing to nearby seed trees and nature's process of plant succession which makes keeping a field free of weed trees a continuing control process. By spot application, however, the owner can use either 2,4-D ester or Ammate as a tool for keeping the invading locust under control at a reasonable cost.

The cost of spraying to control locust using one stub and two foliage sprays amounted to $102.43 for Ammate and $77.88 for Esteron 44. Of these amounts, $60 was for cutting the locust at a rate of 80 cents per hour prior to the first spray (Table 1).

Table 1. Cost to control black locust by chemical sprays

Chemical	Spray Rate Per cent	Spray Rate Lbs. per Acre	Type Spray	Cost of Chemical	Labor Cost Cutting	Labor Cost Spraying	Total Cost
Esteron	10.0	4.24	Stub-June '48	$8.26	$60.00	$4.00	$77.88
44	0.4	0.31	Foliage-August '48	.77		4.00	
(2,4-D ester)	0.4	0.02	Foliage-August '49	.05		.80	
	30.0	55.0	Stub-June '48	20.62	60.00	4.00	102.43
Ammate	30.0	28.0	Foliage-August '48	10.50		4.00	
(Ammonium sulphamate	30.0	6.7	Foliage-August '49	2.51		.80	

The Effectiveness of 2,4-D plus 2,4,5-T on Poison Ivy, Horse Nettle and Certain Shrubs

Homer B. Neville[1]

Variable results were obtained in 1947 by the writer (1) and in 1945 and '46 by Willard (2) when poison ivy (Toxicondendron radicans) was treated under various conditions with different 2,4-D and 2,4,5-T compounds. Beatty (3) cites effective treatments on poison ivy and other woody plants by the use of chemicals combining 2,4,-D and 2,4,5-T in different proportions. There have been conflicting reports on the resprouting of susceptible plants, suggesting the desirability of further work. Pridham (4) states, that, after what appears to be complete kill of top growth, resprouting occurs the following year, possibly from spreading root systems of plants outside the treated area.

Plan of Experiment.

The work here reported was done primarily to test the efficiency of one 2,4-D - 2,4,5,-T mixed chemical on poison ivy. The area chosen for treatment was a fence row with square rod plots extending from the edge of the highway to the border of the field. The plots ran consecutively with untreated checks at the ends, precluding the possibility that the new growth within any but the borders could come from untreated areas. Dry weather most of the summer made for adverse growing conditions. However, the soil was heavy, moisture retentive.

Sherwill Kill, at the rate of 2 pounds of the acid equivalent per acre was applied in water and sprayed at the rate of 80 gallons per acre. giving thorough coverage. Treatment was made during July. Observations were made three weeks later and notes taken on three other woody plants growing in some of the plots. Horse nettle (Solanum Carolinense) grew in all plots.

Summary

Top growth of poison ivy was completely killed by early August. Observations taken again in early October disclosed two new shoots in one of the plots. In the remaining plots the kill seemed to be complete.

Horse nettle showed twisted stems, yellowed leaves and stunted growth. By early October the appearance had changed but little. There had been enough chlorophyll in the leaves to maintain life. Flowering and seeding did not occur in any of the plots.

The few woody plants occuring in some of the plots showed variable reaction. Arrow wood viburnum was completely killed above ground. Regrowth had not occurred by October. Gray or Panicle dogwood was 90% killed. But new growth appeared in early September. Ibota privet showed complete resistance.

Observations will again be made on these plots in the spring of 1950 to determine the extent of new growth of poison ivy. The slight amount of regrowth this fall may indicate lack of complete coverage. Or it may indicate lack of translocation to the entire root systems. One year's results are not conclusive.

[1] Senior Instructor, Department of Agronomy and Farm Management
Long Island Agricultural and Technical Institute, Farmingdale, N. Y.

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OIL SPRAYS CONTROL WEEDS IN CONIFEROUS NURSERIES

By E. J. Eliason*

The writer has previously (1) reported to this conference on the use of oil sprays to control weeds in tree nurseries. The title of this paper, somewhat changed from previous ones (1) (2) is meant to imply that effective control is being practiced in the majority of the coniferous nurseries in this country (3). It does not imply that all the questions or problems have been answered, but on the whole, considering the limited scope of this type of work as compared with agricultural crops, it is believed that a greater part of the possible worked area is being controlled of weeds than any other specific land crop. There is hardly a tree nursery that has not tried control by some type of oil spray, and many, especially the larger ones, are using the method as a regular routine operation.

This paper will be brief and will give only a few high lights of the 1949 experience in the New York State Nurseries. Some 15,000 gallons were used on about 100 million trees. The grass weed species were almost completely eliminated. A wider use of the oil was demonstrated in 1949 as fas as tree species and their conditions was concerned and their susceptibility to damage. Formerly, the larch species were not sprayed as some burning occurred, and with sufficient hand labor available this species was weeded by hand. Also, Scotch Pine was damaged slightly in previous years during the second growing season. In 1949, by keeping the rate of application down, both species were safely sprayed. The light application used was 20 gallons per acre and the heavior 40 gallons per acre. The light rate was used when the trees were just coming up and the seed coats remained on. The larch species, especially in the early stages around the germination period, is sensitive, and great care must be taken to see that the desired rate is applied and also applied equally to all surfaces. The one year old larch was given but one application. The other species and older stock was sprayed when needed at the heavior rate. The number of applications varying from 2 to 7. Weeds are best attacked just when they are coming through the soil surface. The weeds which equal the size of the crop in size generally are difficult to kill completely without possible crop injury.

The foreseeable problem in the coniferous tree seedbeds, which remain intact for 2 or 3 years, is the group of weeds not readily attacked by oil sprays. In the beginning of the spraying practice after the war, the summer grass species was the greatest menace. The oil has generally eliminated the grasses. Now with the grass competition gone these overwinter weeds which germinate late in the summer and fall, gain considerable growth in the fall and remain alive overwinter, and are ready for rapid growth in the early spring. This admittedly is a special problem, but an example of the same problem may be experienced elsewhere.

Now, the operator will show us some Kodochrome slides which tell a story of the weeding problems as found in 1945 and 1946; also how tests were made with spray oils in 1946 and 1947, and finally the method now used to control the weeds in the nurseries.

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Practical Control of Water Hyacinth with 2,4-D Applied by Helicopter and Other Equipment

A. E. Hitchcock, P. W. Zimmerman, and Henry Kirkpatrick, Jr.
Boyce Thompson Institute for Plant Research, Inc.
Yonkers 3, N. Y.

The experimental work dealing with the control of water hyacinth (Eichhornia crassipes Solms.) in Louisiana by means of chemicals was started early in 1948 and was continued through 1949 (1, 2). Within certain limits of concentration (> 0.3 per cent) and rates of delivery (20 to 150 gal./acre) a dose of 8 lb. of 2,4-D acid equivalent per acre caused killing and sinking of hyacinths within 60 days at all times of the year. At this rate of application an amine salt formulation proved equally as effective as the isopropyl and butyl esters of 2,4-D. In view of the favorable results obtained with 2,4-D under experimental conditions, practical control measures were undertaken in 1949 which made use of the helicopter and other large-scale spraying equipment. These investigations were part of a cooperative project between the Corps of Engineers, New Orleans District, Boyce Thompson Institute, and Tulane University. The present report deals with the methods and equipment used successfully in 1949 for the practical control of water hyacinth.

Equipment and Methods

High-volume high-pressure spraying. Gun-type sprayers operated at pressures of 150 to 600 p.s.i. were used to apply sprays from boats and from land. Increasing the size of the nozzle orifice with a corresponding increase in the capacity of the pump from 4 to 35 g.p.m. resulted in an increase in range of effective coverage (for killing hyacinths) from 25 to 60 ft. With the gun-type sprayer it was necessary to deliver the solution at a minimum of about 200 gal./acre in order to secure adequate coverage of the hyacinths. Spraying at this relatively high rate of delivery with a 1 per cent solution of 2,4-D resulted in considerably more wastage of 2,4-D and required a slower rate of spray rig travel as compared with other spraying equipment.

Low-volume low-pressure spraying. A boom equipped with 4 or 5 Spraying Systems' Teejet nozzles was used in comparative tests where similar sprays were applied by the same equipment to plants in experimental pits (15 X 30 ft.) and to similar plants in canals and bayous. The Teejet nozzle delivers a flat fan-shaped spray. When this type of sprayer was operated at pressures of 20 to 30 lb. p.s.i., the delivery rate could be increased from 5 to 150 gal./acre by increasing the size of the nozzle orifice. Although uniform and adequate coverage of hyacinths was obtained with this equipment, the use of a long boom in practical control operations would probably not be feasible in most cases. However, spraying with a short boom containing one or two nozzles is considered feasible, particularly in patrol maintenance operations, for the spraying of small groups of plants.

Spraying Systems' OC Boomjet nozzle having a 1-3/4 in. pipe connection delivers a flat off-center spray which resulted in uniform and adequate coverage of hyacinths for distances of 10 to 35 ft. depending upon the size of the orifice. By using nozzle tips of different orifice size, a single nozzle delivered sprays at the rate of 5 to 200 gal./acre at pressures of 50 to 75 lb. p.s.i. This type of sprayer was operated from boats and from land.

Spray applications from the air were made by means of a Bell 47-D type helicopter flown at heights of 10 to 80 ft. and at a speed of about 30 m.p.h. Sprays were delivered at a pressure of 40 lb. p.s.i. from a standard Bell boom 23 ft. in length which contained 82 nozzle outlets. In the tests subsequently described, 54 to 64 nozzles each delivering 0.2 g.p.m. were used instead of the full quota. The rated coverage for this machine is 600 acres per day.

Results

Practical control of water hyacinths was accomplished by applying an effective dose of 2,4-D by means of the helicopter, the Boomjet, or the gun-type sprayer. The few plants which in some cases did not receive an effective initial treatment were sprayed later (patrol maintenance spray) with boat-mounted equipment before any noticeable reinfestation had occurred. Booms were used to prevent reinfestation of treated areas by non-treated plants from adjacent waterways. An effective treatment was one which killed all or nearly all hyacinths and caused them to sink within 60 days after the spray was applied. An amine salt containing 4.1 lb. 2,4-D free acid equivalent per gallon (40 per cent 2,4-D) was used in all tests referred to in this report.

The most effective and efficient method of spraying hyacinths was by means of the helicopter. When this machine was flown at a speed of 30 m.p.h. and at a height of about 40 ft., a spray application of 40 per cent 2,4-D killed hyacinths over an area of about 100 ft. The rate of delivery in this case was about 2 gal./acre. Areas several hundred feet in width were treated successively in strips 75 to 100 ft. wide. Sufficient discoloration of hyacinth foliage occurred within 30 minutes to serve as a marker for the helicopter pilot. Tree-lined waterways not over 75 ft. wide were treated in one trip from above the tree tops. In this case the 40 per cent 2,4-D spray penetrated down through the foliage to hyacinths underneath, causing complete killing of the latter from bank to bank. Where only one bank was lined with trees and the width of the canal was not over 75 ft., the helicopter was flown over the central area at a height of about 40 ft.

Helicopter applications of 40 per cent 2,4-D were considerably more effective than substantially lower concentrations (5 to 20 per cent). However, the results with these lower concentrations have not been fully evaluated. Until it is known with certainty that helicopter applications of substantially less than 40 per cent 2,4-D are effective, no attempt should be made to economize by using the lower concentrations. With present information it is not possible to give an accurate estimate of helicopter applications in terms of pounds 2,4-D per acre. The relative proportions of the spray which fell on hyacinths and on the trees are not known. Even in the absence of trees it is not known what quantity of the applied spray goes toward effective killing of the plants as compared to that lost as ineffective drift.

Uniform killing of hyacinths was also accomplished by 2,4-D sprays applied with the Boomjet nozzle. A smaller quantity of spray solution was required per unit area, as compared with the gun-type sprayer, in order to obtain equivalent effects in killing. However, both types of sprayers were used successfully for applying the initial spray as well as for applying patrol maintenance sprays.

Patrol maintenance spraying consisted of applying a subsequent spray or sprays to the relatively few plants not killed by the initial spray and before any noticeable reinfestation had occurred. The gun-type sprayer was used for the patrol maintenance operations since in most cases the waterways in question had irregular margins where it appeared that the gun-type sprayer would be more maneuverable than the Boomjet nozzle for treating scattered groups of plants. Where only a few thousand plants are to be treated, it is believed that small spraying equipment such as a pressure pack sprayer of 3 to 5 gallons' capacity would prove satisfactory. In this case a Teejet or a small Boomjet nozzle could be used for applying a 1 per cent solution of 2,4-D.

Sprays applied at the rate of 8 lb. 2,4-D acid equivalent per acre by means of ground equipment were effective for killing hyacinths at all times of the year, but substantially lower doses (2 to 4 lb./acre) were not effective. Hyacinths were killed more readily during their slow-growing period (August through March) than during the period April through June when growth was most rapid. Regardless of the time of year the sprays are applied, no attempt should be made to economize by using less than the 8 lb./acre rate of application or by using less than 1 per cent 2,4-D when the solution is delivered by means of ground-spraying equipment. Spray treatments that were effective for killing and sinking hyacinths were also effective for controlling alligator weed (<u>Alternanthera philoxeroides</u> [Mart.] Griseb.) which frequently occurred in dense stands together with water hyacinths.

The details of practical control of water hyacinth with 2,4-D together with specific recommendations for initial and patrol maintenance spraying will be published early in 1950.

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CONTROL OF AGROPYRON REPENS WITH HERBICIDES

William E. Snyder, Cornell University, Ithaca, N. Y.

Introduction

Nursery stock frequently remains in a field five or more years and during this period a serious infestation of quack grass (*Agropyron repens*) frequently occurs. Areas heavily infested with quack grass should be made relatively free of the weed before replanting with small nursery stock. If such can be accomplished, the stand of quack grass can be kept to a minimum by spot chemical treatment and/or frequent cultivation.

Previous reports (1, 2) have indicated that both the sodium and ammonium salts of trichloroacetate and ammonium thiocyanate may effectively control quack grass. Use of chemicals in nursery areas, however, must be made with caution because of effects of the chemicals on the nursery stock which render them unsightly and thus unsaleable from the nurseryman's viewpoint. Formative effects, burning and other injuries have been reported following use of ammonium thiocyanate, trichloroacetates, 2,4-D, and other chemicals.

Unpublished results (3) indicate that fall application of ammonium thiocyanate as a contact spray will kill the above ground parts of quack grass which is wetted by the herbicide, but will not injure the underground rhizomes. Carlson and Moulton (1) have suggested that trichloroacetates are absorbed by the foliage and translocated to the underground parts. The herbicidal action of the two chemicals is apparently different.

It was decided, therefore, to apply the various chemicals to the soil and exposed rhizomes of quack grass following cultivation. If such treatments should effectively reduce the incidence of quack grass, nursery crops could be planted and the remaining quack grass and/or reinfestation from seeds could be controlled by spot chemical treatments and/or frequent cultivation.

Materials and Methods

The test area selected because of the uniform stand of quack grass was divided into two portions. One portion contained three untreated control plots in which the original ground cover, consisting mainly of quack grass, was left intact. The second area was plowed to a depth of approximately seven inches and thoroughly disked. Plots, 12' x 60', were established in this plowed area. There were three replicates for each of the treatments.

Treatments included cultivation alone and in combination with applications of iso-propyl phenol carbamate (IPC), 2,4-dichlorophenoxyacetic acid (2,4-D), ammonium thiocyanate (ATC), sodium trichloroacetate (STCA), and ammonium trichloroacetate (ATCA).[1] One-third of a given plot received three applications of the treatment, a second third of the plot received two applications, and the remaining third of the plot received only a single ap-

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[1] Chemicals supplied to Cornell University as follows:
2,4-D - Naugatuck Chemical Co., Naugatuck, Conn.
ATC - Rochester (New York) Gas & Electric Company.
ATCA and STCA - E. I. duPont de Nemours & Co., Wilmington, Dela.
STCA - Dow Chemical Co., Midland, Mich.

plication. The first applications were made June 24-28, 1948, and successive applications were made at thirty day intervals. The treated areas were cultivated with a rototiller prior to each application of the chemicals.

Rates and method of applying the chemicals were as follows:

IPC - 2, 4, and 6 pounds per acre. Chemical mixed with two bushels of coarse grade white quartz sand and broadcast over the area. Uniform distribution of the chemical was assumed because of the uniform distribution of the white sand.

2,4-D - 1.6, 4.8, and 8.0 pounds of acid equivalent per acre in the form of triethanolamine salt. Application was made at the rate of approximately 200 gallons of solution per acre.

ATC - applied at the approximate rates of 250, 500, 750, 1000, and 1250 pounds of ATC per acre in the form of crude solution obtained as a by-product in the manufacture of coke. The solution contained approximately 30 per cent thiocyanate and solutions applied to the various plots were 100, 200, 300, 400, and 500 gallons per acre rates.

STCA and ATCA - applied at the rate of 100 pounds (acid equivalent) of the chemical per acre. The material was applied in solution equivalent to 200 gallons per acre.

In August, 1949, one replicate of those plots which showed a marked reduction in quack grass were rototilled, otherwise the test areas have not been treated since the last applications of chemicals were made in August, 1948. Counts of "crowns" of quack grass and of "other grasses" and of broadleaf weeds were made in October, 1948, and in May and October, 1949. Only the data regarding quack grass is presented in this paper.

Results and Discussion

The results of cultivation and of cultivation plus chemical treatment of the soil are presented in Table 1. The data are presented as percent of quack grass present compared with that of the untreated areas. It would seem that reduction of quack grass to 10 percent or less of the untreated areas is a fair measure of success. Such areas could then be planted either with a cover crop or with a hoe crop such as nursery lining out stock which can be hoed or cultivated at frequent intervals to keep the weed under control.

Cultivation only at the start of the experiment resulted in a significant increase in the number of crowns of quack grass. Areas cultivated at weekly, bi-monthly, and monthly intervals failed to effect a material reduction in the stand of quack grass. However, the more frequent and the longer the total period of cultivation, the greater the reduction of quack grass. Weekly cultivation for two and three months reduced the stand of quack grass significantly as indicated one month after the last cultivation. However, the following May, there was such an increase in quack grass that the treatment would not be a satisfactory method of control.

IPC applied at the rates of 2, 4, or 6 pounds per acre and 2,4-D at rates up to 8.0 pounds per acre reduced the stand of quack grass by a maximum of 50 percent one month following the last application. Data for the May, 1949 ob-

TABLE I

Effect of various treatments on the stand of crowns of quack grass compared with untreated areas. Data expressed as percent of untreated areas and based on the average of nine square foot areas for each replicate. October 1948 and May 1949 data based on three replicates; October 1949 data on two. First application made June 26-28, 1948 and successive applications made at 30 day intervals.

Treatment	October 1948			May 1949			October 1949		
	No. of Appl.			No. of Appl.			No. of Appl.		
	1	2	3	1	2	3	1	2	3
Ammonium 250#/A	119*	9	0	157**	17	0	116***	10	12
thio- 500#/A	61	4	0	105	10	0	157	10	20
cyanate 750#/A	4	0	0	5	0	0	36	3	0
1000#/A	4	0	0	7	7	0	30	31	0
1250#/A	2	0	0	0	0	0	0	0	0
STCA 100 #/A	15	0	0	12	2	0	8	4	0
ATCA 100 #/A	13	0	2	10	0	0	48	10	0
IPC 2 #/A	80	52	72	64	88	79	-	-	-
4 #/A	48	56	67	90	62	74	-	-	-
6 #/A	102	65	57	38	98	141	-	-	-
2,4-D 1.6 #/A	120	137	74	155	153	126	-	-	-
4.8 #/A	111	85	61	103	55	81	-	-	-
8.0 #/A	122	124	67	195	103	72	-	-	-
Cultivation									
Weekly	43	13	7	60	28	33	-	-	-
Two weeks	109	91	50	133	100	78	-	-	-
Four weeks	122	107	80	162	145	126	-	-	-
Initial cultivation only	144			128			143		
No Cultivation	100			100			100		

* 100% represents 5.4 crowns quack grass/sq. ft.
** 100% " 5.8 " " " " "
*** 100% " 9.8 " " " " "

servation period were exceedingly variable. Plots treated with IPC as well as those treated with 2,4-D developed a uniform and dense stand of quack grass during the second growing season. It was obvious prior to October, 1949, when the counts were made, that these two chemicals were not satisfactory under the conditions of this experiment.

Satisfactory reduction in the stand of quack grass was obtained with certain treatments with ATC, STCA and ATCA. One to three applications of STCA and ATCA at the rate of 100 pounds per acre and one or more applications of ATC at the rate of 750 or more pounds per acre reduced the stand of quack grass to a level which would indicate continued control of the weed by frequent cultivation or by spot treatment with ATC, STCA, or ATCA. It should be noted that approximately 700 pounds of ATC are required to maintain control equal to that effected with 100 pounds of trichloroacetate.

During the early part of August, 1949, one replicate series of ATC and STCA was cultivated with a rototiller. Comparison of the stand in plots not cultivated with those cultivated (Table 2) shows that the additional cultivation reduced the quack grass present in plots originally treated with ATC, but resulted in an increase in those plots originally treated with STCA.

Plants grown in soil taken in June, 1949, from the various experimental plots produced normal growth for such test plants as tomato, zinnia, yew, arborvitae, boxwood, viburnum, and privet except for those growing in soil which had received three applications of ATC at rates of 750 or more pounds per application. Thus all plots treated with ATCA and STCA and with one or two applications of ATC at rates of 750 to 1250 pounds per acre resulted in effective control of the quack grass and were sufficiently free of residual effects to permit planting the following season.

Table 2. Effect of a single cultivation during the growing season following application of ATC and STCA on the stand of quack grass. Areas originally treated in June 1948 and at thirty day intervals as indicated. Data expressed as percent stand of intact areas and based on average of 9 square foot areas for each plot. Data of areas not cultivated the second growing season based on two plots for each treatment and of plots cultivated on a single plot.

Treatment		Not Cultivated			Cultivated second season		
		No. of Applications			No. of Applications		
		1.	2	3	1	2	3
Ammonium	250#/A	116	10	12	-	7	0
thio-	500#/A	157	102	20	-	0	0
cyanate	750#/A	36	3	0	0	0	0
	1000#/A	30	31	0	0	0	0
	1250#/A	0	0	0	0	0	0
STCA	100#/A	8	4	0	145	28	2
Initial cultivation			143				
No cultivation			100				

The data obtained indicate that treatments with 750 to 1250 pounds per acre of ATC or 100 pounds per acre of trichloroacetate has resulted in an almost complete destruction of the rhizomes of the original stand of quack grass. Quack present in the plots at the end of the second growing season (October, 1949) may represent growth from some of the original rhizomes which were not destroyed by the treatment as well as new plants developed from seeds either present in the soil or brought in during the course of the experiment. Based on these results, it is suggested that heavy stands of quack grass can be effectively reduced by 1) two to three applications of ATC or STCA in low concentrations following cultivation or 2) by a single application of a high concentration of the chemical following plowing. The single application could probably be accomplished in the fall after the crop is removed from the field. After the original infestation of quack is brought under suitable control, reinfestation could be controlled by 1) frequent (weekly) cultivation, 2) spot treatment with ATC or STCA, or 3) by a single application of the chemical following fall plowing. The method employed would depend upon the crop to be grown in the areas.

Summary

1. Effectiveness of cultivation alone and in combination with application of various chemicals were tested for reduction of a heavy infestation of quack grass.

2. Cultivation at weekly to monthly intervals and one to three applications of IPC and 2,4-D applied at monthly intervals were not effective in reducing materially the stand of quack grass at the end of the second growing season.

3. One to three applications of ATC at rates of 750, 1000, and 1250 pounds per acre resulted in effective reduction in the stand of quack grass to a level indicating a method of controlling the weed. Similar applications at rates of 250 and 500 pounds per acre resulted in variable and less effective control.

4. STCA at rates of 100 pounds per acre applied one to three times and ATCA applied two or three times to cultivated areas reduced the stand of quack grass to less than 10 percent of the untreated areas.

5. A single cultivation of treated areas during the second growing season resulted in the absence of quack grass at the end of the second season for plots treated with ATC. However, STCA treated plots contained more quack grass following the cultivation than comparable plots not cultivated.

6. Test crops grown in soil from the treated areas indicated that the area could be planted the season following the chemical treatments except when three applications of ATC were applied at rates of 750 or more pounds per acre.

7. It is suggested that heavy infestations of quack grass can be effectively reduced by

a) two or three applications of ATC, STCA, or ATCA in low concentrations following plowing, or
b) by a single application of a high concentration of the chemical following plowing.

8. Control of quack grass infestation in areas relatively free of the weed could be controlled, depending upon the crop to be grown, by

a) frequent (weekly) cultivation

b) spot treatment with ammonium thiocyanate or sodium trichloroacetate, or

c) by a single application of the chemical following fall plowing.

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72 - lost

73-lost

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75-1064

EXPERIMENTS IN RAGWEED AND POISON IVY CONTROL

Frederick J. Vintinner
Director, Division of Industrial Hygiene
New Hampshire State Department of Health

In 1947, the New Hampshire State Department of Health began a study to determine existing conditions in the State relative to the occurrence and extent of growth of plants which cause hayfever and the resulting density of pollen in the atmosphere. This study was undertaken for several reasons, among which were the following: (1) A large number of inquiries are received yearly from hayfever sufferers requesting information as to locations in the State which are free from hayfever pollens. There was no source from which this information could be obtained. Previous replies were based on knowledge of locations recognized as being beneficial to hayfever victims due to the trial and error method of exposure; (2) New Hampshire is well known as a recreational State because of the excellent natural features which exist within her boundaries. The State also has a reputation among hayfever patients as a place where relief from their symptoms may be obtained. Therefore, it was desired to evaluate the State as a whole in respect to hayfever plants and the consequent contamination of the atmosphere; (3) There has been no cumulative source of information on the morbidity caused from hayfever. It is well known that such morbidity can cause much discomfort and illness as well as absenteeism and loss of production, especially among industrial groups. It was the intent of the study to determine basic information on the subject and to evaluate existing conditions upon the data obtained from the study; (4) The data obtained would be used to advise hayfever sufferers about areas which were relatively free of hayfever pollens and also could be used for the development of control programs.

The study was organized to obtain concrete data on the growth of ragweed plants and on hayfever pollen density in the atmosphere. During the 1947 season, due to the dealy in obtaining the necessary sampling devices, the study did not get started until June 22, and slides were exposed from that date until October 15, 1947. During this period, we were able to sample the majority of pollens from the grasses and also ragweed, but were too late for the tree pollens. During the 1948 season, the sampling stations were established and slides were exposed from March 15 through October 15, which period covered the entire period of pollination in New Hampshire, with the exception of a few off-season plants which were not known to be causative agents of hayfever.

During the 1947 season, 12 sampling stations were established, being located approximately 50 air miles apart throughout the State. During the 1948 season, 25 sampling stations were set up, located approximately 25 air miles apart. During the 1949 season, sampling stations were operated only during the ragweed pollination period.

These stations were manned principally by local health officers, superintendents of fish hatcheries, town and city officials and other citizens interested in the hayfever problem. Each person operating a sampling device was carefully instructed and frequent visits were made to each station during the first month of operation. The slides were collected every one or two weeks and brought to our laboratories for identification and counting.

The techniques, equipment and methods used for evaluating the density of airborne pollen were those recommended by the National Pollen Survey Committee of the American Academy of Allergy,[1] which consists essentially of exposing greased slides in a Durham sampling device.[2] The slides were exposed daily for a 24-hour period and then the pollens were identified and counted, after being stained with Calberla's solution. We used a 22 mm. square cover glass placed in the center of the slide and 5 trips across the cover glass, using a compound binocular microscope with 10x objective and 10x eyepiece. The counts were computed and reported on the basis of the number of pollen grains of each species found on a square centimeter of slide area. Approximately 10,000 slides were exposed and examined by this method.

Ragweed pollen index figures were calculated from the findings for the 1947 and 1948 seasons by O. C. Durham, Technical Director, National Pollen Survey Committee, American Academy of Allergy.

Ragweed Pollen Incidence for New Hampshire
Arranged According to Zones of the State

	Number	Location	Index
ZONE NO. 1 (Northern)	1	Colebrook	1.00
	2	Berlin	11.00
	3	Whitefield	0.48
	13	Pittsburg	0.61
	14	Errol	0.41
	15	Groveton	2.00
ZONE NO. 2 (Central)	4	Conway	4.00
	5	Warren	1.00
	6	Lebanon	17.00
	16	Bath	3.00
	17	Lincoln	3.00
	18	Holderness	4.00
	19	Ossipee	2.00
ZONE NO. 3 (Southern)	7	Laconia	12.00
	8	New London	1.00
	9	Concord	5.00
	10	Keene	7.00
	11	Exeter	26.00
	12	Nashua	20.00
	20	Rochester	19.00
	21	Charlestown	10.00
	22	Hillsborough	4.00
	23	Manchester	10.00
	24	Rye	13.00
	25	Hinsdale	5.00
	26	New Ipswich	6.00

Reconnaissance surveys for ragweed growth were made covering the entire State during the 1947 and 1948 seasons. This was done chiefly by the State Health Department personnel who travel throughout the State. Ragweed growth densities were classified into four categories, namely, None, Light, Medium and Heavy. The basis for this classification was established arbitrarily by using the most dense growth of ragweed found in New Hampshire as a measure of Heavy classification. As a result of these reconnaissance surveys, each town and city was classified according to the density of ragweed growth. These classifications have been given in our reports. 3,4.

No instances were found in the State where areas of ragweed exceeded more than one-tenth of an acre. The areas classified as Heavy consisted essentially of a one to two foot width of ragweed growth in the burm, running continuously along highways and along town and city streets. Growths were also evaluated as found in cultivated areas such as in corn fields, bean patches, vacant lots, near telephone poles, driveways, commercial buildings, filling stations and residences. Ragweed attained its heaviest growth in the center of the largest cities and towns. Many resorts and hotels in an otherwise ragweed-free area had ragweed growing immediately beside the buildings throughout the entire service area at the rear of the establishemnt. It was noted in many areas that ragweed grew along the edges of main highways in strips averaging one to two feet in width. However, when the sides of the highway were shaded by trees or heavy growths of grasses, shrubs or ferns, no ragweed was seen.

The results of each sampling station were published[3,4] and the pollen densities were shown in graph form. It is interesting to note the seasons of pollination, particularly for the trees, grasses and for ragweed.

As a result of these studies, a great deal of interest was developed in the subject of hayfever in the State and many organizations, city and town officials requested us to assist them in programs of ragweed and poison ivy control. In addition, at our suggestion, the State Highway Department expressed a willingness to conduct an experimental program of ragweed and poison ivy control along State highways. During the 1947 and 1948 seasons, an experimental area was selected for control spraying with 2,4-D solution.

An examination of the roadsides in this area one month after spraying revealed that all ragweed and poison ivy growth within the highway right-of-way had been destroyed by the chemical spray. Spraying was done with a 150-gallon tank mounted on a State body truck. An orchard type spray gun was used which necessitated the operator's walking beside the truck to apply the spray. The spray consisted of a 40 per cent 2,4-D liquid solution which was an esterone of 2,4-D with the spreader added by the manufacturers. The cost of spraying was two dollars for each mile of highway which included both sides of the road. Expense included labor, chemical and the operating cost of the truck and equipment. Approximately 150 gallons of solution were sprayed per hour. Acre costs were difficult to compute because of the type of spraying done; however, 150 gallons would cover approximately one acre. It is interesting to note that one part of the experimental area east of Lancaster required three days for control spraying during the 1947 season. This same area was covered by one day's spraying in 1948. The time reduction was due to a decrease in the density and incidence of ragweed growth caused from the previous year's control spraying. The same men, equipment and chemical were used in the 1948 season as were used in the 1947 season.

In addition to the State Highway's experimental control program, several towns and cities in the State have conducted programs for the control of both ragweed and poison ivy.

The town of Lancaster sprayed all public property during the 1948 and 1949 seasons. At the same time, knapsack pumps were made available to the citizens for spraying their own property. These control programs resulted in the town of Lancaster being changed from a classification for ragweed growth from Heavy to Light.

The town of Jefferson has controlled ragweed and poison ivy by chemical spray in most of its areas, principally through the interests of various hotel owners. As a result of these activities and the work of the State Highway Department in this area, the town has been classified as having a Light growth for short ragweed.

The town of Bethlehem controlled ragweed by chemical spray method in July of 1949. The spraying was done with Indian back pumps and 2,4-D solution. Bethlehem was listed as being Light for ragweed during the 1948 survey. A survey a few weeks after the spraying resulted in the reclassification of Bethlehem from a Light to a Negative category. The total cost of this spraying in Bethlehem, covering approximately 74 miles of the town roads, was slightly over $100 for the chemical, equipment and labor.

The town of Littleton initiated a spraying program in July of this year which resulted in the town being reclassified from a Medium to a Light category for the growth of ragweed. The cost of spraying all public property in the township of Littleton was less than $150, which included equipment, labor and chemicals.

The city of Laconia sprayed the sides of all streets and highways, including those at the Weirs, in July of this year. The project took six days for completion and was carried out by the Laconia Chamber of Commerce. The Laconia Fire Department furnished a tank truck and driver and the City Department personnel did the actual spraying. In addition, the Boston and Maine Railroad sprayed all of its right-of-way inside the city boundaries and extended some distance outside the edge of the roadbed. The New Hampshire State Highway Department also cooperated in this program by spraying all the ragweed and poison ivy in the rights-of-way under their jurisdiction in this area.

This control program has changed the rating of the city of Laconia to a Light growth of ragweed. Laconia was rated as being heavily infested with ragweed in 1947 and 1948. The entire cost of the spray program was $60 for the 2,4-D solution. Labor and equipment was made available by the City departments.

In addition to these town and city control programs, several resort hotels in the northern part of the State have initiated and conducted control programs on their own.

As part of the educational campaign to encourage towns and cities to inaugurate ragweed and poison ivy control programs, the State Department of Health published several articles in their monthly bulletin, "Health News," and also prepared posters on the recognition of the plants, as well as on methods of control. This educational material was sent out to local health officers, city and town officials and to officers of various regional associations. The greatest interest in this subject was found in those areas which had a large tourist and recreational business. As stated before, the State Health Department published the results of both the atmospheric pollen densities and the results of the reconnaissance surveys for ragweed growth. It has been indicated to the town and city officials that this Department will provide technical assistance for the development of control programs. In addition, the Department will re-evaluate any town or city in respect to the hayfever situation after they have conducted control programs. If it is proven to the Department that the control programs were effective, then the name of the town or city would be included in the Department's list of ragweed-free areas.

Personnel of the Department have given many talks and lectures before civic and social organizations on the subject of ragweed and poison ivy control. From the interest already observed throughout the State, it appears that perhaps New Hampshire may accomplish a great deal in the development of continuous control programs. Towns and cities are giving consideration to including items in their annual budgets for the purpose of financing control programs for both ragweed and poison ivy. If such programs can be made part of the annual budgets, then they will be placed on a more permanent basis.

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POISON IVY CONTROL PROGRAM OF GARDEN CLUB OF MALBA

by

Mrs. William T. Ingram
(Civic and Conservation Chairman -- Garden Club of Malba)

The Garden Club of Malba, a member of the Federated Garden Clubs of New York State, is composed of fifty-five members who live or have recently lived in the community of Malba. One hundred and fifty families comprise the community of Malba, which is located in the Borough of Queens, on the East River near the Bronx-Whitestone Bridge.

At the February 1948 meeting of the Garden Club of Malba it was decided to cooperate with the Queens Golden Anniversary Committee clean-up Campaign with a program designed to be of special benefit to Malba residents. The Civic and Conservation Chairman was instructed to proceed in developing a program aimed at the eradication of poison ivy.

The Malba Association (membership over one hundred families) was asked to cooperate in the work. A committee made up of members of both Garden Club and Malba Association worked out preliminary plans. A questionnaire was sent to all residents asking if they could recognize poison ivy, whether they had any on their own premises or in adjoining vacant lots, if any member of the family had had ivy poisoning -- and when. Forty written responses were received. Thirty-seven thought that there was a poison ivy problem and that something should be done about it. Twenty-three families had ivy poisoning in 1947.

A reply to a letter addressed to Dr. Mustard, Commissioner of Health of New York City, assured the club of advisory service. Mr. Philip Gorlin, Supervisor, Weed Control Unit of the New York City Health Department, made a survey of the hundred acres in Malba and found poison ivy on thirteen and a half acres "growing prostrate on the ground, as short shrubby growths and climbing on trees, stumps, fences and buildings." The amount was estimated to be equivalent to four acres of solid ivy coverage. Mr. Gorlin outlined the program for spraying and the amount of chemical to be used. He also emphasized the necessity of clearing the lots of debris, fallen trees and woody growths in order to treat the ivy successfully.

The joint Committee then launched an educational campaign: mailing to all residents a map showing areas infested with poison ivy; a letter from a physician resident of Malba, Frank L. Horsfall, Jr., M. D., describing ivy poisoning, the cause and control methods; excerpts from the United States Department of Agriculture Bulletin Number 1972; post cards announcing clean-up week; a circular explaining the full program with cost estimates; and a request for a donation of not more than $5.00. Forty-eight per cent of Malba families responded with a contribution of three hundred dollars.

Three newspapers in Queens also gave news items about the community program.

The Clean-up Campaign was scheduled for May first through the ninth. A limited number of residents contributed a great deal of personal effort, a jeep, station wagon and other tools and equipment. Additional manpower was needed and hired for cutting and clearing. The Department of Sanitation, Borough of Queens was most cooperative and collected all boxed rubbish.

The poison ivy spraying program began May fifteenth under the supervision of the garden club chairman. A solution made from triethanolamine salt of 2, 4-D 40% acid content was used. The solution was mixed in a twenty gallon galvanized iron garbage can. Four ounces of 2,4-D concentrate were mixed with eighteen gallons of water (equivalent of 1.6 pounds of 2,4-D acid per acre). In shady areas the strength of the solution was doubled. The spraying was done by hand with a four gallon Hudson Industrial pressure sprayer. One man was hired for this work.

We planned to cover the thirteen and a half acres of unimproved or vacant lots. In addition our policy was to spray in gardens and occupied lots at the request of and under the supervision of the owner. 2, 4-D was used because we were advised that it would be less dangerous to gardens. The hand spray was chosen because it could be controlled more easily than a power spray.

The rainy season of 1948 delayed completion of the first spraying until the end of June; it produced a luxuriant new growth of poison ivy as well as a heavy overgrowth of grasses. A second spraying was started immediately and continued into August. Altogether it took a hundred and sixty hours to complete the two sprayings. An inspection of the sprayed areas made in late September showed that all the foliage actually hit with solution was killed. In spite of some misses, we had hopes that there would be very little regrowth the next year.

In 1949 the Garden Club was prepared to carry on the spraying program and received some financial aid from the Malba Association. Early in May survey was made and the amount of growth of poison ivy was disheartening. Where the ivy had grown as vines or heavy shrubs, these particular plants were killed, but there were many new shoots at the base. In the lots that had been mowed previous to any control or once during 1948 there was a good mat of small new shoots.

We were advised that the ester of 2, 4-D might prove more effective and it was used for the first spraying from May fifteenth to June fifteenth in a solution which would provide 2.4 pounds of 2, 4-D acid per acre. Parts of three areas were sprayed with the amine. The results appeared no better with the ester than with the amine salt, so we returned to the amine for the second spraying July second through August seventh.

The amount of money spent is itemized as follows:

Expenses

	1948	1949
Publicity	$ 26.93	$000.00
Clean-up	149.00	000.00
Spraying Program		
Labor	131.36	$152.92
Equipment	11.00	6.82
Chemical	39.78	15.40
Spraying Total	182.14	175.14
Total	358.07	175.14

The cash outlay is not representative of the total amount of work done on the poison ivy spraying program. Some equipment was donated; and all supervision and many hours of spraying were contributed by Malba residents.

When a weed control program is carried on by a garden club or other civic organization, it is necessary that the organization be encouraged by evaluations and recommendations of some official agency. We must know if the program is producing results which make it possible to carry on; we must know what needs to be done so costs can be estimated; we must prepare budgets and plans for the next year's work. Since July we have been entreating the Health Department to give us such an evaluation, but to date (November 15th) we have not received the requested aid.

My personal observations are these: After spraying for two seasons there is about one-half as much poison ivy as before. The most noticeable results were obtained in gardens, hedges, trees, and fences where the poison ivy was climbing and had many leaves per stalk. In sprayed lots that have been burned, a lush new growth appears covering the burned spots, possibly from stimulation of two-year-old dormant seeds or stimulation of roots. The reduction of the quantity of poison ivy has made no appreciable difference in the time required for each successive spraying.

The usual recommended formulation expressed in pounds of acid-equivalent per acre is bunglesome and could be expressed more easily as ppm (parts per million) or ounces per gallon when used for poison ivy control. The efficacy of the spray is reduced because the solution rolls off the poison ivy leaves when disturbed by wind, rain, or animals or humans walking through the ivy.

It was stated before that twenty-three families answered a questionnaire that some member of the family had ivy poisoning in 1947. Current information has just been obtained. In only five of these families was ivy poisoning reported in 1949. Three cases were reported by men who contacted the ivy in their own gardens. One woman said she got it from her dog as she does each year. One case was a child who found a patch of ivy out in center field on the playground -

a spot that had never been reported or sprayed. But these statistics could never be correlated with the amount of ivy growth. Rather they show the value of the educational aspects of our campaign. Adults as well as children have watched what was being done and learned what the plant looked like and exactly where it was growing.

Also, our efforts aided appreciably in mosquito control. We were able to point out specific spots where mosquito larvae were found such as in crotches and holes in trees, in cans and jars found in rubbish and in gardens, in ornamental ponds and in bird baths. Ragweed was routinely sprayed whenever it was noticed.

Although no official estimate of the value of our project has been made, it seems to me to be worth pursuing for at least one more year. So I have recommended to the Garden Club and to the Malba Association that it be carried on as a control program rather than an eradication program. I have also recommended that it be specifically coordinated with mosquito and ragweed control, and with a program of lot and parking-strip maintenance. Such a program should add a great deal to the livability, the recreational uses, the beauty, and general well-being of our community.

THE HISTORY OF THE RAGWEED EXTERMINATION PROGRAM

IN HACKENSACK, NEW JERSEY

Starting with a very small seed which passes through the process of germination and is nourished by the sun and soil, ragweed grows and flourished until it becomes a giant. So, from the seeds of our desire to do something about this health hazard and nourished by our determination to solve this problem, our ragweed extermination program has grown and flourished until it has now outstripped the ragweed itself.

Consideration was first given the ragweed extermination problem in Hackensack back in 1941. At that time the Garden Division of the Hackensack Women's Club initiated a limited ragweed extermination campaign with other volunteer organizations in the City and the City Health Department. The cooperation of the Board of Education and the Boy Scout organization was enlisted. Boys and girls from High School together with members of Boy Scout troops were organized and instructed to go out in groups to cut the ragweed or pull it up by the roots. Of course, while this was very much worthwhile from an educational point of view, it was not very effective from the overall standpoint of eliminating the ragweed.

We found that where the ragweed had been pulled up by the roots it had destroyed it for that particular season. We also found that the weed was more profuse in its growth in those spots the following year than it had been in '41. This was because the seeds that were lying dormant too deep in the ground for germination were brought to the surface and in the next year or two grew in great abundance.

Due to the interest aroused during the summer of 1941 some consideration was given to drafting an ordinance for the purpose of controlling and eliminating ragweed. After a great deal of study with reference to how this ordinance should be drawn, it was felt that because of lack of education of the public in this matter, the time had not arrived when the enforcement of such an ordinance for the control of ragweed was practical. Therefore, consideration of such an ordinance was dropped.

During the war years our thoughts and efforts were concentrated more upon making contributions toward the elimination of dictators than toward the elimination of ragweed. However, the interest that had been created during 1941 and early '42 carried over until the war was won and in 1946 we started gathering information as to the best method of exterminating ragweed.

Dr. Israel Weinstein, who was Commissioner of the New York City Health Department at that time, called a meeting of the health officials of the metropolitan area on July 29, 1946, to consider a ragweed extermination program for this area. As a result of this conference, which a representative of the Hackensack Health Department attended, we were successful in arranging for a conference in Hackensack of the health officials of Bergen and Passaic counties under the auspices of the Bergen County Health Officers Association.

At this conference our speakers were Mr. Alfred H. Fletcher, who was the Director of Environmental Sanitation of the New York City Health Department, and his associate, Mr. Philip Gorlin, Health Inspector in Charge of Weed Extermination of the New York City Health Department. Just prior to this conference Mr. Gorlin made a hurried survey of Bergen County in order to determine, in a measure, the prevalence of ragweed along the roads and on vacant property throughout the county. These two members of the New York City Health Department recommended the use of 2-4D as being, in their experience, the most effective chemical for the eradication of ragweed. The information and suggestions made by Mr. Fletcher and Mr. Gorlin at this meeting added great impetus to our interest in ragweed extermination.

The City of Hackensack had no spraying equipment for the use of 2-4D, so in order to determine as to the effectiveness of this chemical, spraying equipment was borrowed from the Bergen County Mosquito Commission and in certain spots where the ragweed seemed to be growing most profusely, spraying was done. This experiment proved to be most satisfying to the City officials and gratifying to hay fever sufferers. It proved beyond a doubt that ragweed could be exterminated, and convinced those suffering from the effects of the ragweed pollen that we were moving in the right direction.

Our experiment of 1946 was still more gratifying to us in the spring of 1947, for it was found that where spraying had been done with 2-4D, hardly a sprig of ragweed could be found in those patches which were so profusely covered the year before. Therefore, plans were made to buy spraying equipment and after considerable investigation a 50 gallon wooden tank with a one-horsepower Briggs and Stratton engine mounted on steel skids was purchased. A wooden tank was secured because it had been recommended to us as being preferrable to the steel tank because of the corrosive nature of 2-4D.

A general survey was made of the City of Hackensack by the Health Department for the locations where ragweed was growing. This was a most difficult job because of the fact that large patches of ragweed were often growing in backyards and could not be detected from the street. Naturally we were not successful in finding all the spots where ragweed was growing in 1947. Therefore, we have been receiving more and more calls each year by citizens with reference to patches of ragweed that have been overlooked in the spraying program. All such information gathered is spot-checked on a city map and given to the Park Department, which is in charge of the spraying program.

When we speak of operating the spraying equipment for the destruction of ragweed, it sounds very simple. Yet we have found through our experience that to do the job properly it is necessary to have trained personnel for the operation of the spraying machine so that damage will not be done to flowers and shrubbery on private property. If spraying is being done along the street, it is very important that it be done against the wind to prevent the spray from carrying over on to private property. Operators must alos be informed as to the difference between ragweed and other non-obnoxious plants. We have learned that an inexperienced operator of spraying machinery can do a great deal of damage to private property if they do not understand the technique in connection with spraying.

Some newspaper publicity was given to our eradication program, which had its effect upon other adjoining municipalities, where the officials felt that if

Hackensack was endeavouring to eradicate ragweed, which had been definitely established as the cause of so many people suffering with hay fever, they, too, would inaugurate some such program in their own municipalities.

During 1947 an ordinance was once more proposed and passed by the Mayor and Council of the City of Hackensack augmenting our nuisance section of the Sanitary Code, making it an offense to permit poison ivy or ragweed to grow on public or private property.

Perhaps like most other municipalities one of the greatest obstacles in ragweed extermination is the matter of finances. We in Hackensack have had to depend upon the personnel of the Park Department to do our spraying and the ragweed has to be sprayed at a time when a great many other things have to be taken care of in connection with the park system. Therefore, our ragweed extermination program is handicapped for lack of personnel, but progress has been made, and where spraying has been done it has practically eradicated the ragweed. We are in hopes that our 1950 budget will be augmented with additional revenue which will enable us to do a more complete job than we have in past years.

Other municipalities in Bergen County are also taking some action with reference to the elimination of ragweed, but we feel that in order to completely eradicate ragweed in Bergen County it is necessary to enlist the cooperation and support of the County Freeholders as well as every governing body in the county and in that way only can ragweed be exterminated and so reduce the number of hay fever sufferers.

by Frank A. Witt, Health Officer
Hackensack, New Jersey

rp

Dr. Rufus S. Reeves, Director
Department of Public Health
City of Philadelphia

Northeastern Weed Control
Conference - New York City
January 4, 1950

RAGWEED CONTROL AND POLLEN STUDIES IN THE PHILADELPHIA AREA

We began our ragweed extermination program in Philadelphia in the summer and fall of 1947 following a city survey the previous year. We were fortunate to interest the well-known Allergist, Dr. George I. Blumstein, of the Mt. Sinai Hospital Clinic, who has given the Department of Public Health the benefit of his knowledge.

The location of our pollen shelters in 1947 were placed ten to fifteen miles from City Hall. The responsibilities of exposing, collecting and mailing of slides that were placed in the hands of gasoline station attendants nearest our locations led to many errors, both of omission and commission. Among the most blatant were their failure to expose and collect the slides every twenty-four hours and to properly identify their station and date of exposure.

A City-wide block by block survey was carried out by trained personnel from the Department of Public Health, Division of Housing and Sanitation, during the months of June and July, 1948. Each ragweed bearing area was catalogued on a 3" x 5" index card and placed in a permanent file. The card contained information regarding the location of the area, its size, and the relative density of ragweed as compared to other indigenous vegetation. These cards will serve as a basis for judging the effectiveness as well as the duration of our extermination procedures when these sites are re-examined during future surveys. One may thus determine how long it takes for regrowth bearing areas. Due to lack of adequate personnel only about three-fourths of the City was surveyed and catalogued during the year 1949. The remaining area will be completed in the near future.

In 1947, 2-4 D, was used exclusively in concentrations which has been found previously effective for ragweed extermination on 180 acres.

In the spring of 1948 I went to Harrisburg to consult with Dr. Norris Vaux, Secretary of Health, to secure his cooperation in using a similar program in the surrounding counties where the public health personnel is under his jurisdiction. This was agreed upon, and furthermore, he took me to consult with Honorable Miles Horst, Secretary of Agriculture of the Commonwealth of Pennsylvania. The latter agreed to use his offices to educate and help secure the cooperation of the farmers.

Standard pollen shelters were placed around the periphery of the City in unobstructed and accessible sites. Vaseline covered slides were exposed and collected every twenty-four hours during the stated period. No stains were used to expedite pollen identification. The standard slide area of 3.6 sq. cm. was counted on each slide since this figure has a volumetric equivalent (one cubic yard of air) for ragweed pollen.(*1.*2.) The responsibility of exposing and collecting these slides was placed in the hands of a full time employee of the Department of Public Health, Division of Housing and Sanitation. The counting was done by trained technicians of the Philadelphia City Laboratory with one exception, namely, the Inquirer counts which were done by Dr. Jay Spiegelman of the Mt. Sinai Hospital Clinic.

A spot check was carried out on approximately fifty sites that had been sprayed with 2-4 D, during the 1947 season. This was done to determine the effectiveness of our previous spraying and to ascertain the rate of regrowth. Since no estimate of the density of the ragweed growth on these sites had been recorded previously, it must be remembered that the opinions regarding extent of extermination are based purely on memory and on the paucity of ragweed plants that inhabited these sites on reinspection.

The total pollen catch from each of these stations was obtained by adding the daily counts for the period August 15th to September 30th inclusive. These figures showed considerable variability. The greatest catch was obtained at the Northeast and Southwest Airports while the lowest was recorded in our centrally located shelters. This is undoubtedly due to the density and proximity of the pollen-bearing plants in each of these localities. The period of maximum pollen dissemination occurs during the last week of August and the first week of September.

An effort was also made to resurvey areas sprayed in 1947 to note the duration of the exterminating effect of 2-4 D, or the rate of regrowth. It was estimated that seventy of eighty percent of the ragweed plants sprayed with a single application of 2-4 D, failed to show regrowth within a period of one year.

It is evident from the foregoing that pollen counts vary considerably from one section of the city to another and that a single count is not a good index of the pollen concentration in a large metropolitan area. The average count from at least four representative stations might give a more accurate estimate of the atmospheric pollen concentration.

I would summarize as follows:

(1) The results of a ragweed elimination program have been presented. It has been estimated that seventy to eighty percent of the ragweed plants sprayed with a single dose of 2-4 D, failed to show regrowth within a period of one year.

(2) That pollen counts vary considerably from one section of a city to another and that the average of at least four such counts from different localities might give a more accurate index of the atmospheric pollen concentration.

Literature Cited

*1. Preliminary Report of the National Pollen Survey Committee of the American Academy of Allergy on Proposed Standardization of Pollen Counting Technique, J. Allergy, Vol. 17, No. 3, 1946.

*2. Report of the National Pollen Survey Committee of the American Academy of Allergy on a Conversion Factor for Gravity Slides, J. Allergy, Vol. 18, No. 4, 1947.

Cooperation Obtained in Ragweed Control in the Oranges of New Jersey

Carl H. Wendel
(Health Officer, Maplewood, N. J., Board of Health)

I have been asked to discuss with you the manner in which a number of communities bordering Maplewood, N. J. were encouraged by us to engage in a ragweed control program.

Though the title of this paper suggests that the intercommunity ragweed control program was restricted to a group of four communities located in Essex County, New Jersey, and generally referred to collectively as the Oranges, the facts are that the program eventually included communities covering a sizable portion of two counties.

For background purposes, I would first like to give you a brief description of the ragweed elimination program which Maplewood has been carrying out for the past four years.

In the spring of 1946, at the insistence of a group of civic minded citizens that we engage in a more aggressive and more effective ragweed elimination program, we decided, upon recommendation of our Township Supervisor of Parks, to embark on a municipal wide 2, 4-D spraying project.

The money was supplied in the budget of the Board of Health and a crew of three men under the supervision of the Supervisor of Parks was placed at our disposal by the Department of Public Works to do the spraying.

A portable four-gallon-per-minute Hardie Sprayer with one hundred feet of hose and necessary spray nozzles, two knapsack sprayers and forty gallons of 40 % 2, 4-D were purchased.

Maplewood is a suburban community of approximately 24,000 population and an area of about 3 2/3 square miles. There is practically no remaining undeveloped acreage. The open land in the community consists of approximately 875 empty lots, on the average 50 feet by 150 feet, well distributed throughout the entire Township.

Beginning the last week in June, the spraying crew made a street by street survey of each lot, publicly and privately owned, and sprayed whatever ragweed was observed on these lots as well as any ragweed found growing between the sidewalks and the streets. Upon completing this tour, the crew made a second tour in the middle of July to spray any ragweed which they may have missed the first time.

Professor H. R. Cox, at that time associated with the College of Agriculture of Rutgers University, acted in the capacity of technical advisor for and interested observer of our program. Following our first season of spraying, he estimated that we had been successful in destroying better than 90 % of that season's crop of ragweed before pollination.

Since this mode of attack on the ragweed problem was new in our area, our activity was the subject of considerable interest on the part of newspapers having a wide circulation in Essex and Union Counties. Lengthy articles accompanied by pictures graphically presenting every phase of the program presently appeared in many of the papers.

This publicity, together with the fact that a considerable number of health workers in our area had attended a course on weed control sponsored by the New York City Department of Health at New York University in the latter part of 1946 or the early part of 1947, resulted in an increasing number of queries from other communities regarding the details of operation of our program.

The interest exhibited by these communities was aroused by the newspaper publicity and the courses presented at New York University, but the basic motivation for their inquiries was, in my opinion, the hope that this method of ragweed elimination might represent a simpler more effective way of dealing with the problem than the rather cumbersome and generally unsatisfactory procedure being employed at that time.

In New Jersey, the method of handling the ragweed problem consisted of obtaining information as to the location of stands of ragweed through a system of inspection or via complaints from citizens. The owner of the property was then sent a notice to dispose of the weed within a prescribed period of time, and, if he failed to do so, a crew was sent in to cut the ragweed and the cost of the work was assessed against the property.

Frequently, before a community could go through this procedure, the ragweed would have matured and spilled its pollen. In general the method was time consuming and ineffective.

Rather than go into detail about our program with each of the interested communities individually, we decided to hold a field demonstration in June of 1947 at which time we could give them all the full particulars at one time. We then sent out invitations to sixteen communities, having populations ranging from 5,000 to 600,000 people, and located in two counties adjoining our town.

Representatives of ten communities appeared at the scheduled demonstration. No formal lectures or talks were given. The entire program was carried out in the field and lasted for the better part of an afternoon.

Previous to the day of the meeting, our Supervisor of Parks arranged a carefully conceived series of demonstrations designed to show the effectiveness of 2, 4-D as a killer of ragweed.

Immediately following assembly of the group, they were taken to a stand of giant ragweed, half of which had been sprayed with 0.1 %

2, 4-D ten days previously and half of which had been left untouched. This very dramatically presented the effectiveness of the material.

They were then shown a stand of giant ragweed portions of which had been sprayed at two day intervals to demonstrate the progressive changes which occur in the plant with the passage of time following spraying.

Following this they were shown a number of lots, throughout the Township, which, before inauguration of the program had had a profuse growth of ragweed and which at the time of the domonstration had on them only a few isolated plants.

The spraying crew then demonstrated the proper method for mixing the 2, 4-D solution and sprayed a stand of ragweed with the Hardie sprayer and with the knapsack sprayers. While this went on the Supervisor of Parks carried on a running commentary on the most desirable pressure, proper handling of the spray to prevent damage to trees and other broad leaf plants and other technical and practical data on materials used, concentration found most effective, etc.

The final exhibit showed trees and garden plants which had been damaged to show the consequences of improper or careless spraying techniques.

During the entire demonstration, the persons present were given every opportunity to ask questions. Questions on technical and practical aspects of the program were answered by the Supervisor of Parks or the spraying crew and questions relative to finances and the legal implications and responsibilities of spraying on private property were answered by me.

At the conclusion of the program, we gave those present a mimeographed sheet giving a complete enumeration of the material and equipment needed together with a breakdown of the costs of the program. We also offered to give advice and aid to any municipality desiring to inaugurate their own program and volunteered to give their men a brief period of in-service training with our spraying crew if they wished.

In the two years following this demonstration, nine of the ten communities represented have begun programs similar to ours. In addition, some communities not attending the demonstration have done so.

It is obvious from this discussion that our success in getting communities to engage in a ragweed elimination program did not arise from a carefully preconceived plan to attain this objective but rather to the fact that we took advantage of an interest which developed originally without our active encouragement.

The aid and counsel which we extended to the communities bordering us had a twofold motive: (1) a sincere desire to be of help to our neighboring communities and (2) a selfish realization that the more of our neighboring communities who engaged in such projects the less ragweed pollen we might reasonably expect to blow over from their community into ours.

Our program thus has two intermediate objectives and one major objective. The first intermediate objective is to eliminate, in as far as it is possible, the ragweed plant from our community. From our experience thus far, it appears certain that we are accomplishing that. The second intermediate objective is to develope a gradually increasing circle of relatively ragweed free communities about us. So far, we have reason to be very much encouraged that this will develop in chain reaction fashion and that this objective will be attained.

Our major objective, the reduction of our ragweed pollen count, is one about which I can give no conclusive evidence to date. The success, partial success or failure to attain this objective can only be determined eventually by the pollen counting program which we have been maintaining, along with our ragweed elimination program, as an integral part of the wider and more comprehensive study now being carried out by Dr. Matthew Walzer and his associates at the Jewish Hospital in Brooklyn.

Progress Report on Highway Weed Control Projects of 1949

H. H. Iurka, N. Y. S. Dept. of Public Works, Babylon, L. I.
and A. M. S. Pridham, Cornell University

One of the costly items of maintenance along highways is that of mowing, particularly along structures such as guard rails where this operation must be done by hand methods. Although actual cost data are not available, the opinion has been expressed that treatment with chemicals to control vegetation along guard rails might be done as frequently as three times in one season and still be a more efficient method than mowing. During the 1949 season, field tests were set up, using various herbicidal sprays and dusts with the objectives (a) of eliminating all plant growth for a period of six weeks or more, and (b) to restrain plant growth to a height of 18 inches or less, the effect to last for a period of six weeks at least following date of application.

Procedure

Level areas adjacent to state highways were selected in three districts of New York State. One district was that along the Sunrise Highway on Long Island near Babylon and is referred to in this report as the Babylon plots. A second area was located at Belgium, New York, northwest of Syracuse and adjacent to Baldwinsville, and is referred to as the Syracuse plots. A third group was located along Route 12E at Watertown, New York and is referred to as the Watertown plots. The grasses predominant at Babylon were fescues while at Syracuse blue grass and timothy were common with occasional areas of quack grass and orchard grass. Blue grass and timothy were predominant in the Watertown plots.

In each district the plots were in three areas or series. Each series contained 34 plots of 22 treatments and 12 untreated or control plots. The plots were arranged within each series so that every third plot was a control plot. Treatments were randomized within the above plan. There were three plots of each treatment at each of the three districts. Individual plots were 10 feet wide and 20 feet long. Sprays were applied by highway maintenance crews using 3 gallon sprayers with special aluminum guns holding 3 Monarch nozzles delivering a flat spray at 25 pounds pressure maintained by carbon dioxide released through valves set for 25 pounds. Dusts were applied by hand.

Weather conditions during spraying were as follows:

Babylon:

May 3 - heavy rain during the morning preceding operation, fair and windy during the afternoon.
May 4 - fair and warm.

Syracuse:

May 10 - fair and cool, 44° F. at noon, windy.
May 11 - fair and warmer than the 10th.

Watertown:

May 18 - partly cloudy, warm and windy with very little rain during the preceding three weeks.

May 19 - heavy rain in the early morning followed by partly cloudy, warm weather.

Treatments were repeated after six weeks or when growth of grass required it. No second treatment was made at Watertown while Syracuse plots were retreated July 6 and Babylon plots August 1. A list of treatments and results is given in Table 1.

In a season of low rainfall, three chemicals killed the top growth of all herbaceous vegetation and prevented resprouting for a full summer period, May to October. Seedling weeds were present by late autumn. The chemicals are Atlacide, Polybor chlorate and Sodium chloride.

Top kill of all herbaceous vegetation was obtained with Sodium trichloroacetate when two treatments were made at Syracuse and at Babylon; a single treatment was successful at Watertown.

Borascu treatments were sometimes effective and the intensity of the effect appears to increase as the season progressed.

Growth of grass was retarded by repeated treatment with herbicidal oils when adequate volumes are used or with oils reinforced with pentachlorophenol. Repeated treatment with low rates of sodium trichloroacetate gave limited response. No one chemical treatment gave satisfactory control in all plots for more than six weeks.

Growth of tall weeds was serious in Watertown in July when chicory and meadow salsify were abundant. During July in Syracuse, goldenrod, New England aster and milkweed exceeded 18 inches in height and were seldom controlled. Response is summarized in Table 2.

The chemicals used for eliminating all weed growth for one year could, of course, be used to treat the weeds listed in Table 2. However, where grasses are to be dwarfed without actually killing them, the removal of tall weeds is imperative, particularly with reference to their growth during the fall of the year. The 2,4-D isopropyl ester 10.88 pounds of acid equivalent per acre controlled all of the weeds excepting the milkweed. Oil-pentachlorophenol mixtures do not appear to give good control of milkweed. Sodium trichloroacetate used at 89 pounds to the acre resulted in dead milkweed without regrowth of tops in 1949.

Table I. List of herbicides used, rate of application, type of response and effectiveness expressed as per cent of plots rated as responding.

Herbicide and rate of application Acre basis	Type of response K - Top kill all R - Retarded grass O - No change	Babylon District 5/3-6/20 6 weeks	Babylon District 5/3-10/15 Season	Babylon District 5/3 & 8/1 6 weeks	Syracuse District 5/18-6/30 6 weeks	Syracuse District 7/6-8/20 6 weeks	Watertown District 5/18-7/1 6 weeks	Watertown District 5/18-10/15 Season
Group A. Objective to kill all vegetation								
Atlacide (one treatment only)								
871 lbs. in 453 gal. water	K	100	100	-	100	-	100	100
1742 lbs. in 653 gal. water	K	100	100	-	100	-	100	100
Borascu								
4356 lbs. dry	K	100	-	100	66	100	-	-
5227 lbs. dry	K	-	-	-	-	-	33	66
6543 lbs. dry	K	-	-	-	33	100	-	-
Polybor Chlorate (one treatment)								
1307 lbs. in 870 gal. water	K	100	100	-	100	-	100	100
Sodium chloride (one treatment)								
10890 lbs. dry	K	100	100	-	-	-	-	-
Sodium trichloroacetate								
327 lbs. in 435 gal. water	K	100	100	100	100	100	100	100
89 lbs. in 109 gal. water) and 3.4 gal. Dinitro 4)	K	100	-	-	-	100	100	100
Group B. Objective to retard growth of grass								
Oils								
Socony Vacuum 975A 44 gallon	0	40	00	33	00	00	33	33

Table I (Continued). List of herbicides used, rate of application, type of response and effectiveness expressed as per cent of plots rated as responding.

Herbicide and rate of application Acre basis	Type of response K - Top kill all R - Retarded grass 0 - No change	Babylon District 5/3-6/20 6 weeks	Babylon District 5/3-10/15 Season	Babylon District 5/3 & 8/1 6 weeks	Syracuse District 5/18-6/30 6 weeks	Syracuse District 7/6-8/20 6 weeks	Watertown District 5/18-7/1 6 weeks	Watertown District 5/18-10/15 Season
Oils								
Socony 44 gal. in 109 gal. water	O	33	00	33	00	33	00	00
" 88.4 gal.	R	66	33	66	00	33	100	100
Esso Weed Killer 45, 32 gal.	O	33	00	00	00	00	00	00
" " 32 gal. in 82 gal. water	O	00	00	33	00	00	00	00
" " 82 gal.	R	66	50	100	00	66	66	66
Pentachlorophenol Formulations								
18% concentrate 5 gal. - (9 lbs.) and Socony Vacuum P.D. 975A 17 gal.	O	33	00	66	00	00	33	00
18% concentrate 32.3 gal. (54 lb.) and Socony Vacuum P.D. 975A 35.7 gal.	R	66	50	66	33	66	100	100
18% concentrate 32.3 gal. (54 lb.) and Esso Weed killer 45 35.7 gal.	R	100	33	100	00	00	66	100
Shell 130 27.2 gallon	R	66	33	100	00	33	33	33
Herbicidal NP 18.7 gal. in 58 gal. water	O	00	00	00	33	33	00	00
Sodium pentachlorophenate 218 lb. in 653 gal. water	O	50	00	100	00	100	00	33
Sodium trichloroacetate 20 lbs. in 109 gal. water	R	33	00	33	33	00	33	66
20 lbs. and 3.4 gal. Dinitro 4 in 109 gallon water	R	66	00	66	33	66	33	33

Table I (Continued). List of herbicides used, rate of application, type of response and effectiveness expressed as per cent of plots rated as responding.

Herbicide and rate of application Acre basis	Type of response K - Top kill all R - Retarded grass 0 - No change	Babylon District 5/3-6/20 6 weeks	5/3-10/15 Season	5/3 & 8/1 6 weeks	Syracuse District 5/18-6/30 6 weeks	7/6-8/20 6 weeks	Watertown District 5/18-7/1 6 weeks	5/18-10/15 Season
Group C. Objective broadleaf weeds								
2,4-D isopropyl ester								
3.4 gals. in 10.88 lb. acid	0 Grass	33	00	33	66	33	00	00
in 163 gallons water	K B.L.W.	100	66	66	33	33	100	100

Table 2. Response of tall herbaceous perennial weeds to herbicides selected to slow down growth of grasses.

Weed	2,4-D isopropyl 10.88 lb.	Oil	Oil-P.C.P. Mix.	Sod. TCA 89 lb. + DN	Sod. TCA 20 lb. + DN	Sod. TCA 20 lb.
Asclepias syriaca Milkweed	Slow or none	No	Slow or none	Died	Slow	Slow
Aster spp. New England aster, etc.	Died*	No	Slow Growth	--	--	--
Cichorum Intybus Chicory	Died	No	None	Slow Growth	None	None
Solidago canandensis Goldenrod spp.	Died	Slow No	Slow Growth Control	Died	Slow Growth	Slow Growth
Trapopogon pratensis Meadow Salsify	Died	No	None	Slow Growth	None	None

* This refers to the top growth of the plant. No regrowth was evident this year.

Table 3. Application of herbicides along guard rails under highway operational procedure. N. Y. S. D. P. W. Babylon, August 1949

MATERIAL AND APPROXIMATE RATE PER A.	LOCATION	DATE
Polybor chlorate	Montauk Hwy.	8/11/49
2300 lb. + 1150 gal. water		
1160 lb. + 580 " "		
580 lb. + 290 " "		
330 lb. + 165 " "		
Shell Weedkiller 130	Glen Cove Rd. N. Hempstead Tpke.	8/12/49
143 gal. + 6 1/3 gal. 2,4-Dester + 11 gal. Triton + 970 gal. water		
29 " + 1.2 " " " + 2 " " + 200 " "		
20 " + 0.9 " " " + 1.5 " " + 130 " "		
15 " + 0.7 " " " + 1.1 " " + 100 " "		
Sodium Trichloroacetate 70%	Sunrise Hwy. Ext. Montauk Hwy.	8/18/49
520 lb. + 15 gal. 2,4-D ester + 7.5 lb. Swerl + 1400 gal. water		
104 " + 3 " " " + 1.5 " " + 300 " "		
52 " + 1.5 " " " + 0.75 " " + 150 " "		
7B 50% + 7B-D 50% of General Chemical Co.	Sunrise Hwy. Ext. Montauk Hwy.	8/18/49
117 gal. + 936 gal. fuel oil #2		
23 " + 198 " " " "		
17 " + 134 " " " "		
12 " + 94 " " " "		
Chipman's Chlorax	Montauk Hwy.	8/19/49
1500 lb. + 1500 gal. water		
700 " + 700 " "		
350 " + 350 " "		
200 " + 200 " "		

Operational Spraying on Guard Rails

Preliminary tests were made under actual operating conditions along the highways in Babylon district. The work was done August 11 through 19. Results were inspected several times and final notes made October 1. The treatments are listed in Table 3. All treatments resulted in excellent top kill including grass, goldenrod and Halls honeysuckle. Only one treatment was required to furnish control for August, September and October. New green grass foliage appeared within three weeks in most plots as also occurred following May treatments.

Spraying was done from standard tree spraying equipment. A four foot boom held by a man riding on the spray rig. The boom was held 3 feet above the ground. The truck travelled at speeds ranging from 1 to 10 miles per hour which was found to be the maximum speed for efficient operation.

SUMMARY

1. Applications of Atlacide, Polybor chlorate, Sodium chloride and of Sodium trichloroacetate made at the rates listed and in a season of deficient rainfall resulted in top kill of all vegetation without resprouting during the summer.

2. Seedling growth in late autumn indicates the probable need of yearly treatment.

3. Repeated application of appropriate amounts of herbicidal oils, of herbicidal oils reinforced with pentachlorophenol or repeated treatment with sub lethal amounts of sodium trichloroacetate reduce growth of grass but are less successful in killing or reducing the growth of tall growing weeds such as goldenrod, milkweed, New England aster, chicory and meadow salsify.

4. Treatments leading to the control of grasses must be reinforced with chemicals that will kill or control the growth of tall growing broadleaf weeds. the 1949 test would indicate the need of further work on the control of milkweed. No one treatment resulted in adequate control without serious injury to the turf.

5. The variability of the results in the three districts may be due to climatic conditions but the predominant grasses also differed. Further tests are needed for final evaluation of several treatments in their effect on the individual grasses.

6. Preliminary tests under actual highway operational procedures gave satisfactory results from August applications without serious injury to guard rails, signs, or markers.

DICHLORAL UREA (EXPERIMENTAL HERBICIDE 2) AND SODIUM 2,4 DICHLOROPHENOXYETHYL SULFATE (EXPERIMENTAL HERBICIDE 1) AS SELECTIVE HERBICIDES.[1]

Lawrence J. King[2]

Dichloral urea (Experimental Herbicide 2) is a member of a new class of chemical growth substances producing definite and characteristic formative effects in grasses and in certain dicotyledonous groups such as the legumes; and with proper dosage is lethal to these groups of plants. In this respect, it is similar to the trichloroacetates.

This new chemical is a white crystalline solid with a melting point of 191°C. (dec.). It is very slightly soluble in water, with considerable solubility in the cyclic ketones such as isophorone. Preparations of the micronized material with an inert diluent and a wetting agent have made satisfactory spray suspensions. The low solubility in water is a definite advantage since heavy rains following application would not leach the chemical out of the soil. Where suitable, it could also be applied as a dust. The material is non-corrosive and toxicological tests on rats revealed that in single oral doses none died or lost weight after a dosage of 31.6 gm./kg.

Experimental Herbicide 2 has been most satisfactory in soil treatment applications for the control of annual grasses in certain crops, and at higher rates for the control of perennial grasses. Susceptible grasses include the crabgrasses (Digitaria spp.), rye (Secale cereale), and brome grass (Bromus sp.); while certain species of Panicum, rye grass (Lolium multiflorum), and blue grass (Poa pratensis) are all more resistant to the lower application rates.

In Table 4 is a comparison of Experimental Herbicide 2 and sodium trichloroacetate on the germination of lawn grass seed. Table 5 illustrates a soil treatment test for crabgrass control where about 90% control was obtained with 5 lbs./acre. At that time, the remaining 10% of the seedlings showed none of the characteristic formative effects. In the field, rates of 5-10 lbs./acre have given excellent crabgrass control--the degree of control depending upon the moisture level of the soil. In Table 6, a comparison with isopropyl phenyl carbamate (IPC) is made, and at that field moisture when IPC was almost totally ineffective, Experimental Herbicide 2 gave good control. Field tests on three crops are shown in Table 7. Beets and turnips were quite resistant at 5 lbs./acre. Annual rye was killed by rates of 10 or more lbs./acre.

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1. This research was sponsored cooperatively by Boyce Thompson Institute for Plant Research, Inc., Yonkers 3, N. Y., the Carbide and Carbon Chemicals Corporation, New York 17, N. Y., and the Seabrook Farming Corporation, Bridgeton, N.J.

2. Senior Fellow in Plant Physiology. Grateful acknowledgement is given to Mr. Thomas Finn for conducting the field plot work.

The results of a large scale field test on table beets at Seabrook Farms are given in Table 1. Here rates of 10 lbs./acre had no effects on the yields of the beets and grass control was reasonably good in view of the fact that a somewhat resistant species of Panicum was the dominant weed. Cabbage (Table 2) and other members of the Cruciferae appear quite resistant to rather high rates; this is also true for members of the Cucurbitaceae.

Species of annual crabgrass appear to be the most sensitive to low rates (5-10 lbs./acre) of any grasses yet encountered. Experimental Herbicide 2 is effective as a soil treatment prior to germination or following germination when the seedlings are in the two to three-leaf stage. Since bluegrass is rather tolerant, low rates of Experimental Herbicide 2 have been used on this type of turf for crabgrass control (Table 3). Two applications, each of 5 lbs./acre made on April 30 and on May 16, gave reasonably good control without marked injury to the turf. Further testing is needed for full evaluation of this practice, however. Perennial grasses such as Bermuda grass can be controlled with 50 lbs./acre, while 50-100 lbs. will control quack grass and Johnson grass.

Since Experimental Herbicide 2 is a suspendable material and has been shown to remain on the soil surface for varying periods of time, the time required for complete control may be extended over a period of several months at least in the case of the perennial grasses. This longer period of effective action, together with its non-corrosive action to metals and non-irritation to the operator, make it a valuable aid in the control of undesirable grasses. Further studies on turf and on perennial grasses are desirable as well as investigations on such tolerant crops as members of the Cruciferae (cabbage, turnips, radishes, etc.); members of the Cucurbitaceae (watermelon, cucumbers, cantaloupes); table beets, potatoes, and cotton. Formulations of Experimental Herbicide 2 with other herbicides for special uses may also be desirable.

Table 1. Soil Treatment Test for the Control of Weeds in Beets

Chemical lbs./acre		Yield Data: Ave. total wt. of rep. samples in lbs. No. rep.	Yield Data: Ave. total wt. of rep. samples in lbs. So. rep.	Weed Counts: Ave. total # weeds/sq. ft. No. rep. Grass	Weed Counts: Ave. total # weeds/sq. ft. So. rep. Grass	Weed Counts: % Control of check No. rep. Grass	Weed Counts: % Control of check So. rep. Grass
E.H. 2	10 lbs.	49.7	40.0	6	2	65	72
E.H. 2	6 lbs.	38.2	40.0	7	2	59	72
Check		34.0	47.2	17	7	0	0

rep. = replicate

Beet seed (var. Detroit Dark Red) was planted on May 9, 1949, three days later, chemical applied as a suspension in water at rate of 40 gallons per acre. Weed counts taken on June 11, 1949. Plots cultivated on June 13 and July 14. Yields taken on August 16 were based on the average total weight in pounds of topped beets in eight, twenty foot rows per plot. The north and south replicates each consisted of two 20'x 20'plots.

Table 2. Tests on cabbage at Belle Glade, Florida

Rates lbs./acre	Cabbage Yields: No. heads	Cabbage Yields: Average weight per head in lbs.
1-1/4	26	1.42
2-1/2	34	1.58
5	27	1.48
10	11	0.90
Check	27	1.59

Plots were 200 square feet in area on muck soil. Chemicals applied three days after planting the seeds. Fifty-two days later, a second application was made to each of the plots, thus the total amounts are double those given in the table.

Table 3. Dichloral Treatments on Established Turf for Crabgrass Control

	Sum total crabgrass in measured linear length: Transect A	Sum total crabgrass in measured linear length: Transect B	Rating value as % control of check: Transect A	Rating value as % control of check: Transect B
E.H. 2 high dosage	0.6'	0.5'	95	93
Adj. check	11.3'	7.6'	0	0
E.H. 2 low dosage	12.2'	11.5'	58	66
Adj. check	29.0'	30.0'	0	0

Plots were 20' x 50', with check plots 10' x 50' separating each treatment. Dichloral urea applied as a suspension at 40 gallons per acre on April 27, 1949, and again on June 16, 1949 at 80 gallons per acre. Data taken on October 4, 1949. The high dosage refers to the five pound application applied on April 27, and June 16; the low dosage of three pounds applied on these same dates.

Table 4. Soil Treatment Tests on the Growth of Lawn Grass Seed and Turnip Seed.

Compound	Average height measurements expressed as % of the controls			
	0.1%		0.01%	
	Grass	Turnip	Grass	Turnip
Dichloral urea (E.H. 2)	37	92*	71	96*
Sodium trichloroacetate	28	76*	71	88*

A weighed amount of seeds (50 mg.) was planted in 4-inch clay pots. Three days later, the chemicals at the indicated concentrations were watered on the pots--40 ml. per pot. Ratings made 19 days later. Asterisks indicate reduced germination of turnip seeds.

Table 5. Soil Treatment Test of Dichloral Urea on the Germination and Growth of Crabgrass.

Chemical	Normal Crabgrass Growth as % of Check	Normal Broadleaf Growth as % of Check
4016		
1 lb./acre	27	71
5 "	10	40
10 "	5	24
15 "	0	19
25 "	0	17
50 "	0	14
100 "	0	6

Flats of soil, 10" x 13" (0.9 sq. ft.) were treated with suspensions of the chemical at rates indicated in 30 cc. H_2O per sq. ft.

Table 6. Weed Control in Field Plots.

Rates/acre		Crabgrass No. as % of Check	Broadleaves No. as % of Check
Dichloral urea	1	39	91
	5	6	89
Isopropyl phenyl	1	100	100
carbamate	5	84	81

Plots were 50 sq. ft. in area. Counts were taken in six squares 6" x 6".

Table 7. Test of Dichloral Urea onRye, Beets, and Turnip in Late Plantings at Boyce Thompson Institute Farm.

Rate in lbs./acre	Height as % of Check		
	Rye	Beets	Turnip
$2\frac{1}{2}$	42	100	100
5	18	97	100
10	3	55	81
33	0	50	80
100	0	67	36

Plots were 50 sq. ft. in area separated by check strips $2\frac{1}{2}$ feet wide. Seeds planted September 24, chemicals applied September 27. Height measurements taken 66 days later on December 2.

Sodium 2,4 Dichlorophenoxyethyl Sulfate

(Experimental Herbicide 1)

Detailed laboratory and greenhouse tests on this chemical have been dealt with previously (Proc. N. E. Weed Control Conf. 1949, pp. 34-36). At that time, the unique properties of this new material were described. Spray or dust applications of Experimental Herbicide 1 to the foliage of sensitive plants result in 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 free-flowing powder, is of course non-volatile, and offers no formulation difficulties since it is freely soluble in water.

It had been observed that when Experimental Herbicide 1 was tested as a water solution in petri dishes for effects on the germination of certain test seeds such as radish, lettuce, or corn, little toxicant action was noted. If soil was added to the dishes, then the material was highly inhibitory to germination. Further tests (Table 10) with sterilized and unsterilized cultures have demonstrated that the conversion of the chemical to a highly active form is caused by soil microorganisms.

Experimental Herbicide 1 is used essentially as a soil treatment for killing germinating weed seeds, both grasses and broadleaves. It must be applied to the soil surface prior to the emergence of the weeds, however. Field tests have demonstrated that at rates of 1½ to 3 lbs./acre applied three or more days following the fitting of the soil, germinating seeds of crabgrass, purslane, carpet weed, lambsquarters, redroot, and low ragweed were killed.

The pre-emergence tests on Ben Fish Baby lima beans at Seabrook Farms are described in Table 8. Here the sprays were applied three days after planting. Excellent weed control was obtained and the yields were higher at both the 1½ and 3 lbs./acre rates than the 2,4-D plots at 1½ lbs./acre and the respective checks. A post-emergence test (six days following planting) on lima beans is described in Table 9. While somewhat later than generally recommended, good weed control was obtained with the 2 lbs./acre rate of Experimental Herbicide 1; while 2,4-D at that rate also gave good weed control, the damage to the beans was severe.

Since aqueous sprays of Experimental Herbicide 1 are relatively inactive on sensitive plants, this chemical has been successfully used as a soil treatment to weed strawberries by Gilbert and Wolf (N. E. Weed Control Conference Proc., 1950). It has also been used on asparagus where weed control was obtained for nine weeks following treatment. Its use in established plantings of the preceding and in potatoes and in small fruit plantings are indicated. The chemical when absorbed from the soil may cause some slight formative effects on such highly sensitive plants as snapbeans, but on more deeply rooted plants or on long established plantings, practically no effects following treatment have been observed. Its use on both field and sweet corn as a soil treatment following planting has been successful. Its use on the larger-seeded crops following planting should be restricted, however, to the period immediately following the emergence of the crop seedling. In view of the unique properties of Experimental Herbicide 1, further tests on the above seeded crops and established plantings should be made during the coming year.

Table 8. Pre-emergence Tests on Lima Beans

Chemical		Yield Data: Total wt. of rep. samples in lbs. No. rep.	So. rep.	Weed Counts: Total # weeds per sq. ft. No. rep.* Bl.	Gr.	So. rep. Bl.	Gr.	% Control of check No. rep. Bl.	Gr.	So. rep. Bl.	Gr.
E.H. 1	1½ lbs.	154	108	2.5	2.0	5.3	2.3	88	93	85	97
E.H. 1	3 "	153	160	0.5	1.0	0.5	0.6	97	96	99	99
Amine 2,4-D	1½ "	126	103	1.0	1.5	5.5	3.0	95	95	84	94
Check		139	73	20.0	29.0	35.0	44.0	0	0	0	0

*Bl. = broadleaves
Gr. = grasses
Rep. = replicates

Plots 0.1 of an acre in area were planted with Ben Fish Baby Lima Beans on June 27, 1949. Chemicals were applied using Kupfer Spray Field Equipment three days following planting at the rate of 40 gallons of water per acre. Carbide & Carbon Experimental Herbicide 1 was applied at rates of 1½ lbs. and 3 lbs. The G.L.F. "66" Formulation (2,4-D triethanolamine salt) was applied at the rate of 1½ lbs. of acid equivalent per acre.

Weed counts were made July 25, 1949, by counting the number of weeds within a 6" square over 24 randomized sections of the treated plot.

The harvest data were based on the total weights of unshelled beans of five replicated sections of the plot. Each replicate contained 80 ft. of bean row. Date of harvesting was September 14, 1949.

All plots were cultivated July 26 and August 12, after weed counts were taken.

Table 9. Post-emergence Tests on Lima Beans

Chemical		Yield Data: Total wt. of rep. samples in lbs. No. rep.	So. rep.	Weed Counts: Total # weeds per sq. ft. No. rep. Bl.	Gr.	So. rep. Bl.	Gr.	% Control of adj. check No. rep. Bl.	Gr.	So. rep. Bl.	Gr.
E.H. 1	2 lbs.	173.5	156.0	0.5	0.6	1.0	2.0	96	70	97	85
2,4-D amine	2 "	54.4	36.5	0.1	0.3	0.1	0.8	100	85	100	94
adj. check		147.6	138.8	11.0	2.0	31.0	13.0	0	0	0	0
E.H. 1	1 lb.	151.5	151.4	1.0	0.9	4.0	2.0	92	55	9	86
2,4-D amine	1 "	75.0	47.5	0.3	0.3	1.0	1.5	98	85	97	87
[illegible]. check		131.0	109.4	12.0	1.5	39.0	14.0	0	0	0	0

Duplicate plots 0.1 of an acre in size were planted with Ben Fish Baby Lima Beans on July 21, 1949. Chemicals were applied six days following planting at the rate of 15 gallons of water per acre, when the bean plants were approximately 2" high and the primary leaves one inch long. No weeds were visible at the time the chemicals were applied. Carbide & Carbon Experimental Herbicide 1 was applied at the rates of 1 and 2 lbs. per acre. The G.L.F. "66" Formulation (2,4-D triethanolamine salt) was applied at the rates of 1 and 2 lbs. of acid equivalent per acre.

Weed counts were made on August 22, 1949, 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 number of weeds per sqare foot and expressed as per cent control of the check adjacent to the treated plot.

The harvest data were based on the weight of the entire plants in five replicated sections of the plot. Each sample contained forty feet of bean row. The total weight is the addition of the five samples harvested in a single plot. The date of harvesting was October 27, 1949.

All plots were cultivated August 30, 1949, after weed counts were made.

Table 10. Corn Root Elongation Test

Unsterilized Dishes	Ave. cm. of root growth of 50 seeds	% Inhibition
E.H. 1 in water at 0.01%	7.7	0
E.H. 1 in soil at 0.01%	1.3	81
Check in water	6.5	0
Check in soil	6.7	0
Sterilized Dishes		
E.H. 1 in water at 0.01%	7.2	0
E.H. 1 in soil at 0.01%	7.2	8
Check in water	5.6	0
Check in soil	7.8	0

Duplicate 6" petri dishes, each containing 25 corn seeds (var. Wisconsin Silver King) were treated with 20 ml. of solution. The soil series contained 5 gms. of air dried soil per dish. Both solutions and soil (except unsterilized series) were added to the dishes before sterilizing in a steam autoclave. After sterilization, the seeds were placed in the dishes and were stored at 21°C. for seven days.

Address of Dr. P. V. Cardon, Agricultural Research Administrator, U. S. Department of Agriculture, before the fourth annual Northeastern Weed Control Conference, New York City, January 4, 1950.

An opportunity to speak before this group--the fourth annual Northeastern Weed Control Conference--is indeed of unusual interest to me. Your group activity in coordinating research work and information, and in getting people together to seek possible courses of action, parallels in a very large way part of my job as research administrator for the Department of Agriculture. And because we in the Research Administration have so broad an interest in weed control, we naturally are vitally interested in what you are accomplishing in this field.

It is difficult to speak of the bigness of the weed control problem without becoming trite. This problem is as old and broad as agriculture itself. When I think of the costly work weeds have caused farmers and other agricultural workers down through the centuries, I am reminded of a bit of Greek mythology. You may recall the story of Pandora's box. According to one version of this myth, Prometheus--a Titan of mythology--stole fire from heaven for earthly man. In addition to the personal punishment meted out to Prometheus, the gods created Pandora--mythology's first mortal woman--as a revenge on man for the theft. Pandora, by opening a certain box, let into the world all evils and diseases, but also hope. Mythologically speaking, I have always felt that weed seeds were one of the worst evils let loose by Pandora's curiosity.

Nevertheless, the research man, along with other workers in agriculture, today recognizes weed control for what it really is: a major problem of extremely broad scope which will require for ultimate control the full-scale measures that usually are reserved for complete eradication programs. To put it another way, no half-way measures will do.

This realization of the weed problem has not been accompanied by adequate control measures in the past, nor is it today. But I think we are making some progress.

Weeds, like diseases and drought, comprise one of the major hazards the farmer meets in producing his crops. It has been estimated that the cost of controlling weeds is at least as great as the losses from insects and plant disease combined. And that cost must be reckoned in billions - not millions - of dollars.

On the whole, research directed at the control of crop diseases, for example, has been carried forward in a thorough manner with fine results. The reports of research workers are full of accounts telling of new and continuing developments that have met successfully the challenge of some disease that hitherto had been an economic catastrophe, or at least had threatened a major crop. On the other hand, our research on weed control has been less consistent, and certainly far less comprehensive. This has been due partially because other research has seemed of a more pressing nature. And perhaps, because of man's long association with them, we have been inclined to accept weeds as a necessary evil.

Whatever the reason, research on weed control has received new impetus the past few years. We know that this intensified interest in weed research has been spurred on by fairly recent discoveries in methods of chemical control. And I am inclined to believe also that farmers are becoming more and more concerned with measures that will help cut their production costs now that farm prices seem to be in a period of adjustment.

This new attention is coming from many quarters--and rightly so--because the weed control problem is not one that can be bested by any one single group or agency. The Department of Agriculture with its not inconsiderable research resources fully recognizes this, along with the magnitude of the problem. The experience and resources of many agencies will be required to achieve complete weed control, for the problem is one that gets into many fields of endeavor. Much more is involved than just the factors affecting the control of plants. Weed control is tied in closely with practices carried out by farmers under the so-called action programs. It is closely allied with the legal aspects of regulatory work which affect the movement of agricultural seeds in interstate commerce and the handling of weeds in local communities. It has broad implications for the industry that manufactures and distributes materials and equipment for weed control. It more and more is becoming part and parcel of the research programs of many Federal and State agencies. And it is assuming greater importance in the channels of educational agencies that reach out to the farm.

And when the farmer himself is considered, weed control work takes on even more significance--for ultimately he is the person on whom the burden of practical weed eradication and control falls. He must, in fact, bridge the wide gap between the laboratory and practical application of research on the farm. He has to integrate the results of his weed control work with all his other activities...with his crop rotation and land use practices, with his participation in crop adjustment and price support programs, with his consideration of practical "farm economics" and all the other phases of our modern day's complex farming. In a way, the farmer acts as a one-man pilot plant for applying weed research to field conditions. And he must do it at his own expense.

If nothing else, the farmer's interest in weed control, along with the responsibility we expect him to assume, highlights the fact that research agencies must get together to see that the job is done in the most effective and efficient manner possible. To accomplish this, agencies with activities having a bearing on the problem must make weed control work, an integal part of their programs. The handling of grazing lands under the authority of the Forest Service, and management of rights-of-way along REA lines are but two examples that point to the need for an interagency attack on this universal problem. Agencies outside the fold of the Department of Agriculture also have a direct interest in this problem. In this respect, the Department of the Interior with its broad public land activities has recognized the problem and is carrying on important weed investigations in cooperation with the Department of Agriculture. Looking at it from the overall standpoint, we must treat weed research as part of the wide variety of Government facilities available to the farmer today--and for its most effective use we must bring together the efforts of all interested agencies.

Against the backdrop of the research and other types of facilities we have for attacking the weed problems, we must recognize that some serious obstacles stand in our way. Scattered throughout the width and breadth of our country as weeds are, their seed is distributed from one area to another by many means. Birds and animals, streams and the winds are only some of the natural means by which such seeds are scattered. And man, in developing his transporation systems and other channels of commerce, has added substantially to facilities for the spread of these agricultural enemies.

This throws the spotlight on one of the fundamental problems in weed control--that of preventing their introduction on our farms and ranches wherever possible, and of avoiding their spread into new areas once they have become established in others.

Let us examine some of these obstacles to weed control more specifically.

In the movement from one area to another within the United States of grains and feeds which contain noxious and other types of weeds, we have a very efficient means of introducing weeds in the broad manner. The same is true--to a lesser extent perhaps--of feeds and grains imported from foreign sources. To state the situation more exactly, our weed population has multiplied and become more diastrous to our farm industry because we have lacked adequate means (1) to control the movement of weed seeds in interstate commerce through shipment of hay, grains, and feeds, (2) to prevent the use of weed seeds in feeds without first destroying the germination ability of such seeds, and (3) to control the distribution of weed seeds in imported grains and roughage.

Admittedly, these avenues for harmful distribution of weed seeds will be difficult to shut off. But to many who are concerned directly with weed control efforts, they represent facets of our over-all problem that demand our fullest attention.

The situation which centers on interstate commerce of feeds that contain weed seeds is particularly complex and troublesome. This is one of the means by which many of our worst noxious weeds have spread from one area to another in unestimated shipments of grain, hay and other roughage and feeds. I can state a case in point: During the thirties when we had two severe droughts, the Government was instrumental in sponsoring programs under which feed of one kind or another was shipped into distress areas. Some of these feeds were naturally the cheaper kinds, with more weeds in them than those of better quality. This action resulted in extensive shipment of weed seeds into new areas. Farmers whose land never before had been infested by certain weeds now had them to cope with. Such noxious weeds as bindweed, Russian Knapweed, and all the annuals were involved. This example had causes that demanded dramatic and immediate action, of course, but it brought to thousands of farmers a continuing expense and effort which otherwise they might not have experienced. But what happened in the drought years of the thirties in a more or less wholesale scale, continues today under normal conditions. It is a matter that stresses the need to prevent if possible this means of scattering weeds seeds. It also emphasizes the desirability of integrating the activities of agencies to avoid whatever possible actions that hold the possibility of intensifying the weed problem.

Especially difficult in the matter of restricting the movement of weed seeds in commercial channels is the fact that the controlling standards on noxious weeds are State regulations which govern the shipment of seeds into the States themselves. This has been deemed necessary because of the numerous regional, State and local factors involved. But, as you would expect, experience has emphasized time and again the need for greater uniformity in such activities.

For one thing, State noxious weed requirements have been arrived at from many different methods and bases. For example, the number of noxious weeds on State lists varies widely. As many as 140 weeds in total have been designated as noxious. And weeds have been so determined for such reasons as the difficulty of separating the seed from crop seeds...the effect of the seed on the commercial value of a crop...the difficulty of controlling the plant under field conditions...the prevalence of the plants in the State...because of danger of introduction from other States...or even because some people just haven't liked certain weeds. The reasons for holding a weed noxious may be good enough in themselves, but when such determinations and restrictions are multiplied by 48 separate State situations the very goal of noxious weed control may be frustrated. Under conditions that have maintained, for example, States with lower seed standards can very well become dumping grounds for weed seeds from other States. And States with noxious weed requirements not in line with sound, overall weed control considerations make it unnecessarily and improperly difficult for those who ship seeds into such States--and often without any advantage whatsoever in protection to their own farmers.

These problems, of course, reiterate the need for more uniformity in State noxious weed regulations and their application. But on the other hand, it must be recognized that there are some practical problems not easy of solution. What, for example, should not be classified as a noxious weed? In the designation of noxious weeds, we have to recognize that problems arise because such weeds are scattered by many natural means. And there are definite limitations on such matters as whether agricultural seed is available with the required degree of freedom from noxious weeds, or whether it is possible to determine the absence of certain noxious weeds. What I am stressing is that seed analysts, agronomists, weed specialists, seedsmen, farmers, and others need to combine their efforts in seeking ways to iron out the many problems connected with noxious weed control. I would be remiss if I did not mention the work already being done by staff members of the Production and Marketing Administration to bring about more uniformity in State noxious weed control. After work which necessitated development of agreements with the 48 states, the experience of this group has brought out consistently the need for more uniformity in State weed laws. Working toward this end, the group has drawn up a Suggested Uniform State Seed Law as a guide to State legislatures in developing revised seed laws. Needless to say, the suggested State law includes definitions and other measures that would unify and make more effective noxious weed control efforts. The laws of practically all the States have at least in part been patterned after those suggestions.

Another measure taken to bring about more uniformity in noxious weed control has been the development of regional noxious weed lists. Eight such lists have been drawn up. They include 40 weeds, in place of the 140 which formerly had been designated as noxious. Ten Southeastern States have banded together to adopt a regional list in order to encourage more uniformity and greater effectiveness in their noxious weed work.

Preventing the use of weed seeds in mixed feed without first denaturing them is another very important point to be considered in the over-all scheme of weed control. It long has been an industry practice to mix weed seeds with feeds to increase their protein content. Many of these seeds are rich in this nutrient and in oil as well. There is nothing wrong with this practice, except that there should be a means of assuring that the germination ability of the weed seeds is killed before mixing with the feeds. When you think of the millions of tons of mixed feeds used in the livestock industry annually, you realize the full significance of the possibilities of spreading weeds by this means. Here again, it seems to me that there should be measures that would protect farmers from another serious weed danger.

Likewise, we should consider a similar problem that springs from weed seeds that are imported in grains and roughage. Weed specialists tell me that practically all the important weeds of foreign origin--Canadian thistle, Russian thistle, and many others--entered this country in this manner. I am sure that we do not now have all the weeds that exist in foreign lands, and I feel certain that we should take all possible means to avoid getting any more of them. A solution would be to make it impossible for such weeds to find a means of entry into the country.

In discussing some of the obstacles which hinder us from more effective weed control, I have called attention to three of our serious problems. I have not offered solutions to them. I would be first to admit that I am not sure just what mechanisms could best be used to achieve what is needed. But I am certain that those of us who have weed control responsibilities should use our best resources to explore all possibilities for the successful handling of these problems. Perhaps additional efforts can be taken to bring about even more uniformity in local weed control activities. Perhaps something more could be achieved through educational efforts directed toward farmers and various segments of the seed and feed trades. And perhaps in bring together all considerations on possible means of getting at these problems, some thought might be given to appropriate legislative suggestions.

We should be mindful, however, that in the light of previous experience, enforcement of such aids might be of a difficult nature. In the past, we have seen laws become ineffective and break down because of this very weakness. To be a fully useful too, any law must be reasonable to those most affected by it, it must have logic in the public mind, and it must be on a thoroughly workable basis. Nevertheless, we should not let the fear of possible enforcement difficulties stand in the way of considering proper weed control aids. Weeds are of such importance to agriculture that we should not fail to exhaust all feasible opportunities for getting at the over-all control problem.

In this respect, the research and educational facilities of the Department of Agriculture and other agencies concerned with the weed menace represent a very important set of weed control tools. On this roster are the research bureaus of the ARA, and such other agencies as the Forest Service and the Soil Conservation Service of the Department. Then there are the State experiment stations, and industry research departments. Individually, these resources may not seem particularly adequate, but collectively they represent an impressive research front.

In its capacity as research arm of the Department, the ARA has the responsibility of coordinating the research work of its own bureas, and other research of the Department which entails the physical and biological sciences. Also, through the Office of Experiment Stations, it integrates the research programs of the Department with those of the State experiment stations. This, as you may well realize, is responsibility of a very broad nature. But along with this responsibility goes the very real obligation of seeing that all resources are brought to bear on a particular problem. In weed control research, we are striving to keep our program flexible and well-integrated with related fields. This would be true at any time, but the lively public interest in weed control makes it doubly so now.

Some illustration will show you the integrated scope of our attack on the weed problem:

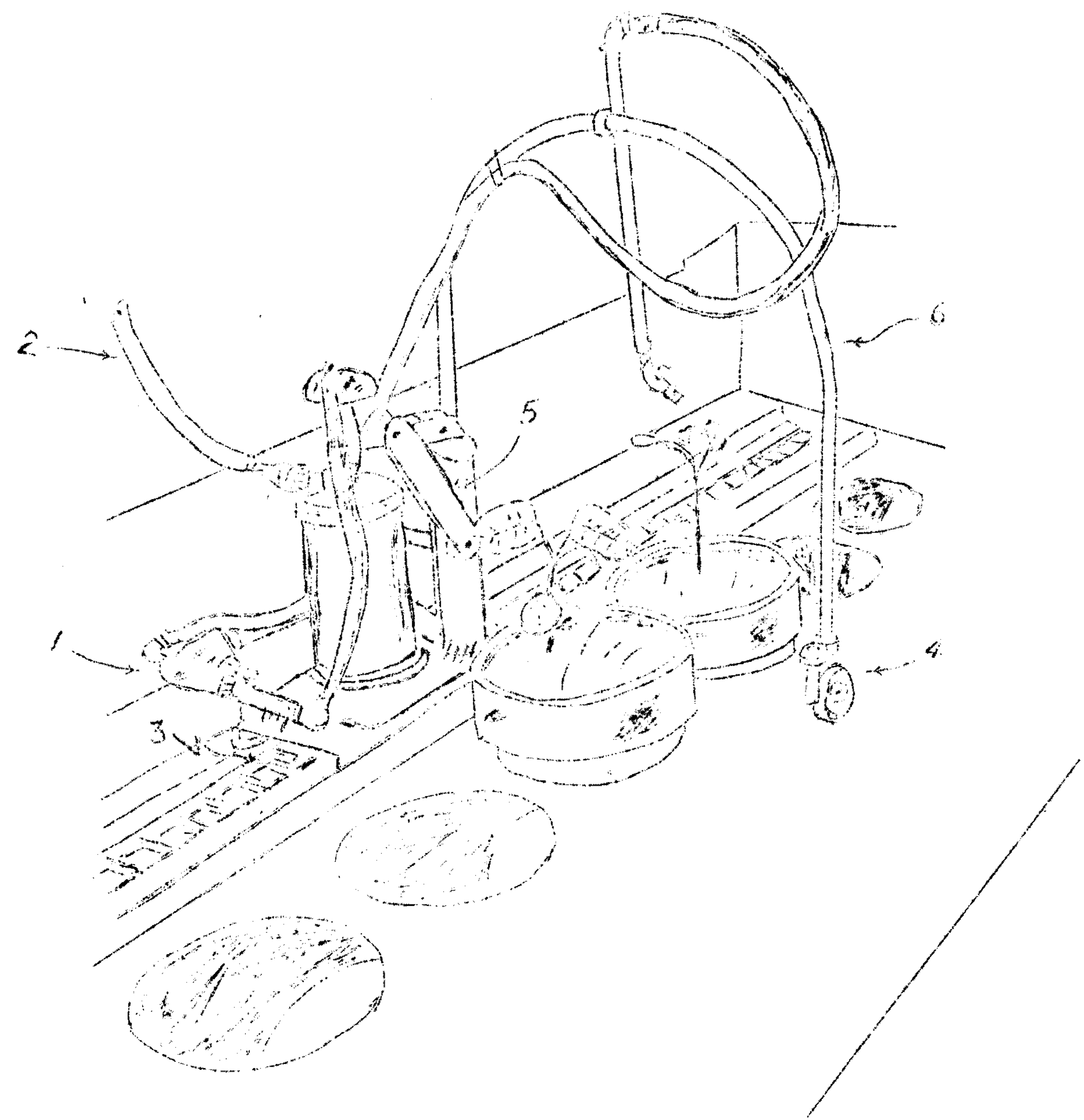
To put the research facilities of the Bureau of Plant Industry, Soils, and Agricultural Engineering on a par with the weed research needed, all such work in the Bureau has been centralized in a recently established Division of Weed Investigations. This division will be responsible for all weed work of the Bureau, and its integrated approach will be open to weed research carried on by other agencies of the Department.

Also, a research panel was recently organized by ARA to align Department research facilities for use in cooperation with state agencies in finding an effective means of controlling the brush problem in the Southwest. In addition to the ARA, the panel includes such agencies as the Soil Conservation Service, the Forest Service, and the Production and Marketing Administration -- all of which have resources that can help do away with a weed problem that is causing southwestern farmers and ranchers drastic losses in usable land.

Of course, not all these efforts are confined to Government agencies. I am aware of the fine work the four Regional Weed Control Conferences are doing in bringing together facilities and resources for weed research. I understand that your Executive Committee--organized for that specific purpose--has already made special recommendations for appropriated funds that could be used to meet emergencies that might arise in weed work.

These efforts point the way to what will be required to do away with the burden of weeds which rests heavily on American farmers. Initiative, resourcefulness, and teamwork will help us to reach the goal of freeing the American farmer from weeds. Of course, the time may never come when the American farmer will be entirely free of weeds, but I for one believe that we should aim our work toward that end. Going back to Pandora, I recall that hope was not abandoned even though all the evils to which man was heir were set loose in the world. We still have time and the tools to get our weed menace under contro. Let us then continue aggressively on the job.

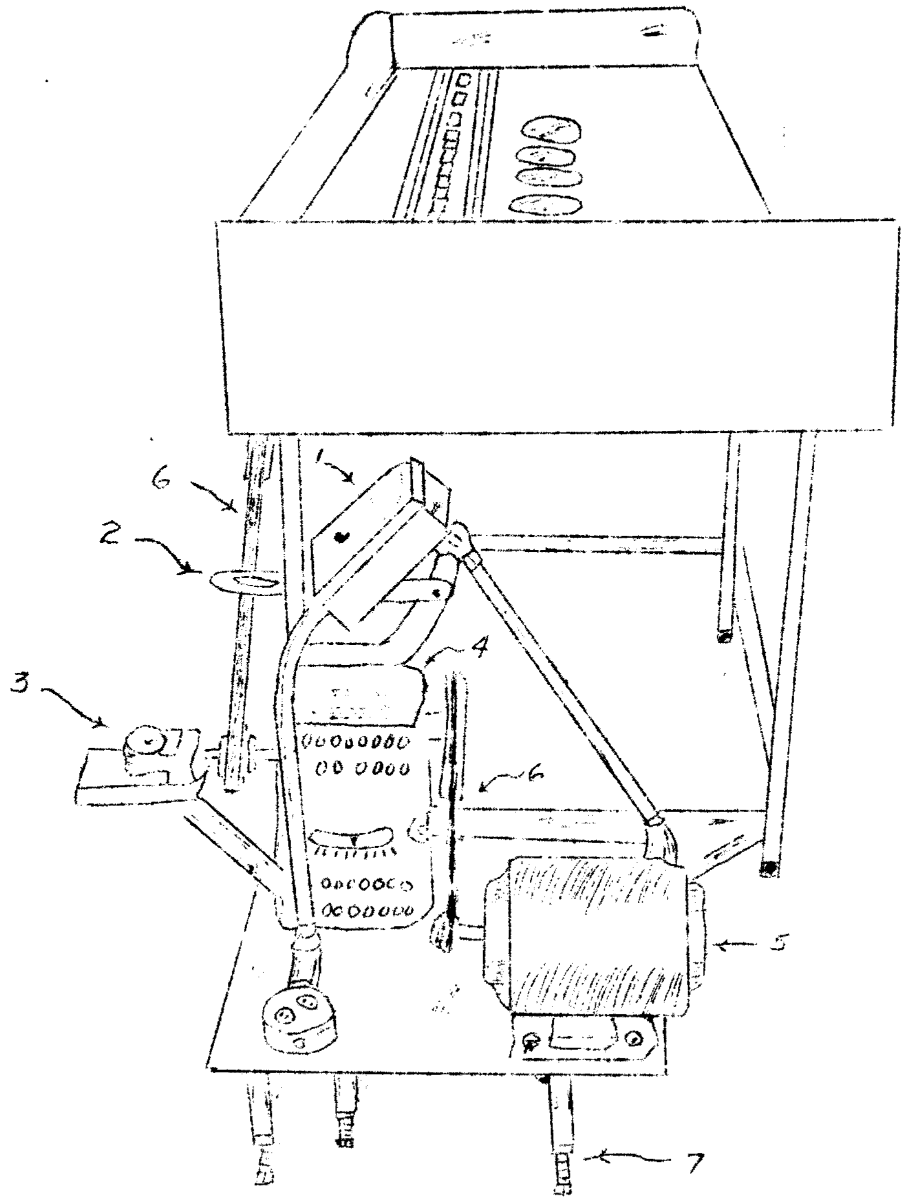
SCREENING TABLE SHOWING CARRIAGE



1. Automatic cut-off valve
2. Air supply line from compressor
3. Engaging lug on chain
4. Dampening wheel
5. Over center latch for securing top of pot and pot to carriage
6. Yoke

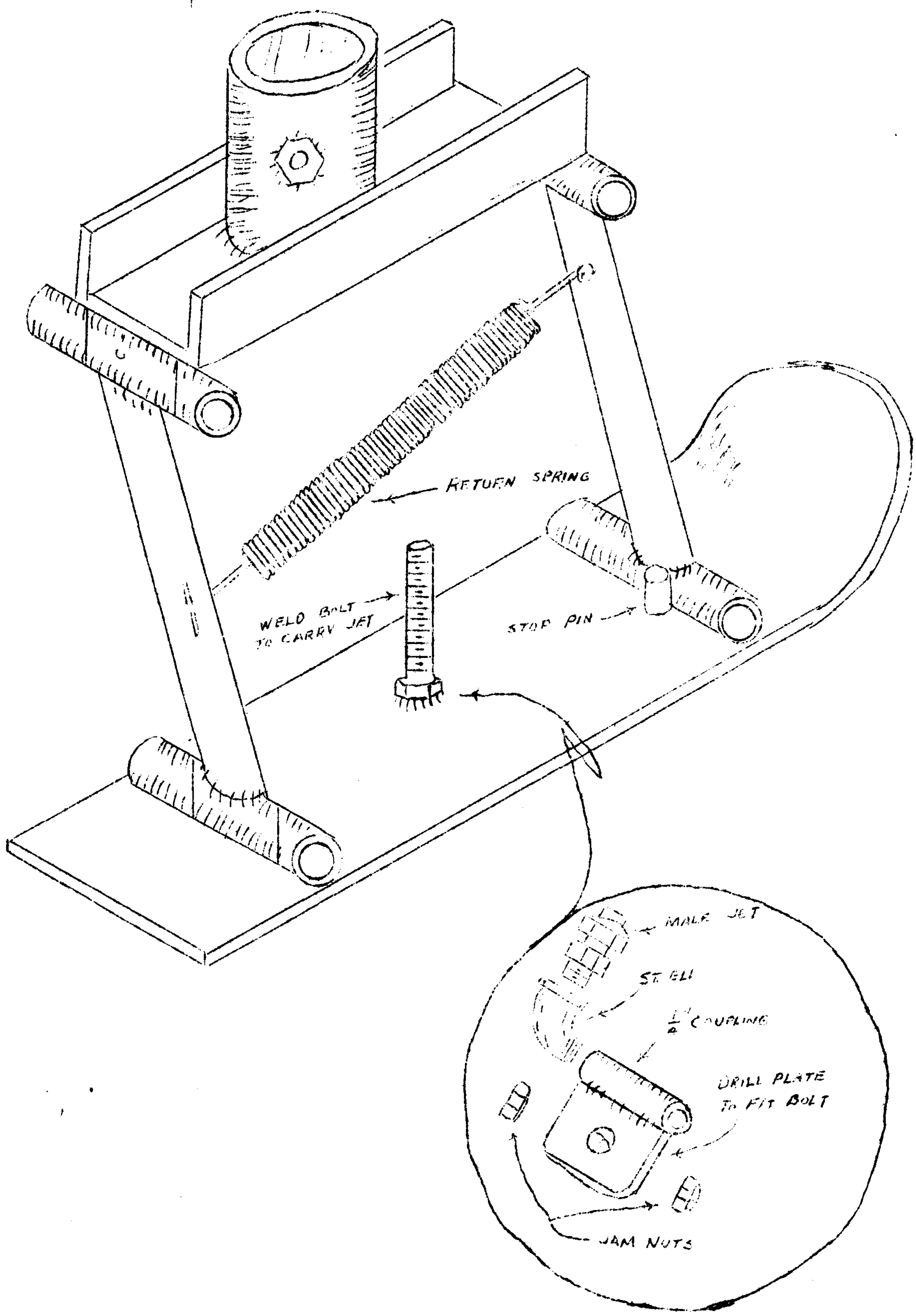
NOTE: Carriage in this sketch is carrying one jet in broadcast position. Two jets can be positioned on the yoke for post-emergence spraying of cotton as described in the discussion.

SCREENING TABLE - DRIVE END



1. Circuit breaker
2. Speed change latch
3. Tachometer
4. "V" belt transmission
5. 1/4 horsepower electric motor
6. "V" belt drive
7. Adjustable legs for leveling drive plate

POST EMERGENCE SHOE



APPLYING CHEMICALS FOR WEED CONTROL WHILE CULTIVATING

R. E. Patterson[1] and S. M. Raleigh[2]

Every producer of corn realizes the need for adequate weed control. They know the loss from weeds exceeds the combined losses from insects, diseases, and pests. That is why every grower possesses and uses a cultivator. Until recently, it was practically the only way of satisfactorily controlling weeds. Many users even indicate increased yields from benefits other than weed control, but this depends upon many factors including soil type, condition, moisture, and many others.

Since the farmer already has this equipment and knows how to use it, we feel it unwise for him to use other methods if he can satisfactorily control weeds with the cultivator. But therein lies the difficulty. If a wet spell or conflicting work prevents his getting the weeds when they are small, it is very difficult to kill those in the row. Also, a fresh supply of weed seeds are brought to the surface with each cultivation.

While our miracle weed killers will not kill most grasses or loosen soils, they certainly will kill most broadleaf weeds even in the corn row. They will not bring up new weed seeds but even tend to destroy those which haven't germinated at time of application. Thus many farmers today are also applying chemicals for weed control.

But why not do both jobs simultaneously and save power, time, labor, and money? While this has seemed the logical combination to us for at least two years, there is no commercial sprayer of this type available with which we are familiar.

How to get it there is our immediate problem. If we apply liquids a simple method is to use a power take-off or belt pulley-driven pump with tank and all accessories mounted on the tractor. The cultivators should be on the tractor when the sprayer is mounted to avoid any interference between cultivator and sprayer when operating.

We have found it desirable to have two positions for the nozzles and spray only an eight to ten inch band over the row. When the corn is less than about twelve inches high, as in figure 1, one nozzle over the row gives satisfactory application. When taller, as in figure 2, the corn leaves protect the weeds and it becomes necessary to use two nozzles per row, one on either side and directed toward the row at a height necessary to cover the weeds. Each boom over the row thus needs to be adjustable in height, width between nozzles, and angle of the nozzles to place the maximum amount of material on the weeds and the minimum amount on the corn.

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1. Assistant Professor, Department of Agricultural Engineering, The Pennsylvania State College, State College, Pennsylvania.

2. Associate Professor, Department of Agronomy, The Pennsylvania State College, State College, Pennsylvania.

When the corn does not touch the minimum height of the tractor, the nozzles should be behind the shovels, but when taller, should be placed in front of the tractor in order to spray the weeds. Spraying after cultivator prevents disturbing the soil after spraying and thus tends to give some residual effect from the 2,4-D. Application in front of the cultivator gives better coverage of the weeds and possibly better kill of the growing weeds.

Most nozzles designed for weed control are satisfactory. If too wide an area is covered with the fan type wide angle nozzle, this width may be decreased by rotating either the nozzle or the tip without changing its relative spray pattern. Hollow cone nozzles should not be used as they tend to give heavy application on the edges. Solid cone nozzles should not be used as they give heavier application in the middle of the pattern.

Adequate care, adjustment, and calculations with proper nozzles and their angle, height, and width must be used to place the recommended amount of material on the weeds. Accurate speed must be maintained. Use the sprayer only when necessary. Once per season should be adequate, and this probably with the last cultivation.

Why not design this same sprayer to handle all chemical weed control problems on the farm by using the following:

1. A broadcast boom for pastures and small grains.
2. Short booms or nozzles over the row for spraying row crops while cultivating.
3. Tubing to a nozzle behind each planter wheel to apply pre-emergence treatment in row crops where weed control is known to be a serious problem.
4. A small hand-operated boom or gun for miscellaneous spraying.

All these jobs can be done with a tractor-mounted sprayer, using the same tank or tanks, pump, strainer, pressure regulator, pressure gauge, valves, and even some of the same hose, nozzles, and pipes.

Apparatus for Spraying Small Plots

S. M. Raleigh and R. E. Patterson
Pennsylvania State College

The application of herbicides in the liquid form to experimental plots is done by applying a definite quantity per area or by calibrating the rate of travel for a definite boom. Both have their advantages and disadvantages.

The rate of travel works well on smooth, hard soil but is not satisfactory on rolling, soft or soil with stones. The plot in general must be longer and requires more turning space between the tiers of plots. We have discarded the boom on the garden tractor for experimental plots.

We believe under our conditions the most uniform application is obtained by having the boom cover the entire width of the plot in one time over. The boom must be constructed so all nozzles start and stop at the same time. This is done by having the solution travel the same distance to each nozzle. It is also desirable to have a means of keeping the boom a definite distance from the weeds or soil.

For ease and efficiency of operation it is desirable to have the solution in a small container with a wide opening which is easily changed with little loss of air pressure.

A home made device fulfilling these requirements has been made by turning a brass cap with a rubber gasket which will fit the container being used. We use mason jars and laboratory chemical bottles. The bottle is held in place by a metal support and shield with a notch in each side going over a cross bar. The metal support is covered with rubber tubing so the container bottle is protected from shock on both top and bottom. The cross bar is drawn up by turning a wing bolt which is held in place by four bolts and a guide on top of the brass cap. The air enters and the solution leaves the bottle through tubing threaded in the brass cap.

Several different size bottles may be used by having different supports and shields.

Pictures showing details of construction are available by writing to us at State College.

Uniform pressure can be obtained by a pressure regulator on an air tank or by carbon dioxide pressure. We use the small war surplus oxygen tank, filling it from a larger oxygen tank or a compresser tank. A good knap sack sprayer with a gauge can be used.

Effects of Chemical Weed Killers on Sweet Corn

Edward K. Bender[1]

The possibility of controlling weeds in sweet corn with the use of chemical weed killers and their effects on sweet corn was studied in 1948 and 1949 by the University of Maryland.

Four varieties of sweet corn were replicated and randomized in treatments and planted May 20, 1949 on a clay loam soil. The varieties used were Golden Cross Bantam, Seneca Chief, Stowell's Evergreen and Tristate. Pre-emergence treatment was made on May 22 and post-emergence treatment when the corn was about 10 inches high.

Table I - Results of Pre-emergence Spraying of Four Varieties of Sweet Corn

Treatment	Yield--Tons/A	Weed/sq.yd.
1-1/4 lbs. 2,4-D acid (Weedaway) + 1 cultivation	3.55	43
3-1/2 lbs. w,4-D acid (Weedaway) + 1 cultivation	2.39	27
Cultivated--No herbicide	3.91	61
Not cultivated--No herbicide	0	143
Difference required for significance @ 1%	.35 ton	

The above results indicate that the yield at the 1% level at the rate of 1-1/4 pounds of 2,4-D acid per acre was as good as cultivation, whereas the over-dose of 3-1/2 pounds of 2,4-D acid equivalent per acre significantly reduced the yield and resulted in harmful effects to the corn. This was evident by observing the tight whorl of leaves on the sweet corn in the 3.5 pound plots. The new leaves did not unfurl until near tasseling time and when they did they were light in color.

Table II - Results of Post-emergence Spraying of 2,4-D on Sweet Corn

Treatment	Yield--Tons/Acre	Weed/sq.yd.
Weed--No More 3/4 lb. acid/A + 1 cultivation	3.77	34
Weedaway--3/4 lb. acid/A + 1 cultivation	3.66	40
2,4-Dow Weed Killer--3/4 lb. acid/A + 1 cultivation	3.82	38
Ester--3/4 lb. acid/A + 1 cultivation	3.62	32
Cultivated	3.91	61
Uncultivated	0	143
Difference required for significance	5%--.36	
	1%--.45	

Results in Table II indicate there is no significant difference in yield of any of the treated plots compared with the cultivated plots under these conditions. This tends to show that it makes little difference which form of 2,4-D is used with respect to yield as long as weeds are controlled. There was no difference between any of the four varieties in any treatment as compared to another variety in that same treatment or between treatments. With post-emergence, grasses are not reduced as they were in the pre-emergence treatment.

[1] Extension Specialist in Vegetable Crops, University of Md., College Park, Md.

In 1949 cyanamid was compared with 2,4-D in weed control on sweet corn in two experiments conducted with canners. The variety of sweet corn named Tendermost was used in both of these tests one of which was on a fine sandy loam soil and the other on a clay loam. Granular cyanamid was applied pre-emergence with a cyanamid spreader, 3 days after planting as was also the pre-emergence spray of 2,4-D.

The experiments were replicated and randomized. Each plot was three rows wide and 500 feet long. Yield records and other data were secured from the center row by averaging the information secured from four blocks of 25 feet of row in each plot. Leaf samples for analysis were secured from the fourth leaf when the corn was at a definite maturity as indicated by the succulometer reading. Actual weed counts were made and these figures were then calculated on the percentage controlled by the treatment using the check as a basis.

Observations

Visible nitrogen stimulation of the sweet corn plants treated with the heavier applications of cyanamid was observed approximately six weeks after application. This was noted throughout the growing season. The plants in the heavy cyanamid plots were taller and darker green than those of the check plots.

Results

Since the difference of results recorded on the two soil types using various chemicals were very similar, the results were combined and are given as one experiment.

Table III - Effect of Various Chemicals used in Weed Control on Sweet Corn, 1949.

*Treatment & Method of Application	Yield in Tons per acre Ears	Yield in Tons per acre Stalks	Average % Nitrogen	Average Succulometer Reading-ml.	% Weeds Controlled Grass	% Weeds Controlled Broad leafed
1/2 pt. Weed-No-More (Post)	1.97			18.30	46.2	24.5
1 pt. Weed-No-More (Post)	2.27	4.54	2.09	18.37	48.9	20.9
2-3/4 pt. Weed-No-More (Pre)	2.32			18.45	8.6	13.8
5-1/2 pt. Weed-No-More (Pre)	2.06			18.35	22.2	20.2
Granular cyanamid-375 lbs/A(Pre)	2.86	6.26	2.59	19.37	34.5	1.1
Granular cyanamid-165 lbs/A(Pre)	2.48	5.62	2.51	19.03	53.6	25.9
Granular cyanamid- 75 lbs/A(Pre)				18.40	98.0	53.4
Check	1.86	4.80	2.01	18.47	--	--
Difference required for significance @ 5%	.60	.77	.37	.62		
@ 1%	.82	1.08	.54	.87		

*Each treatment and the check received 1 cultivation.

Summary

It appears that good weed control can be secured by use of 2,4-D and granular cyanamid, if used at proper rates and methods of application. Cyanamid has the advantage of supplying fertilizing elements to sweet corn which in turn stimulates production on a soil low in these nutrients. It appears that the nitrogen content of the leaves may be increased and that the succulence of the corn may be stimulated based on the results of the work of one year.

Extremely high application of 2,4-D may reduce yield and result in injury to sweet corn.

In light of other tests this year, the effectiveness of weed control with cyanamid is determined to a great extent by the amount of moisture available. During periods of draught, weed control is not effective.

Conclusions

Similar work done using cyanamid on field corn gave increased yields and resulted in a definite nitrogen stimulation. It appears that based on results of one year's work on sweet corn, the application of cyanamid would deserve further trial. More data is needed, before definite recommendations can be made.

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Pre-emergence weed control in corn

S. M. Raleigh and R. E. Patterson
Pennsylvania State College

The 1949 planting season in Pennsylvania was much dryer than normal, so the control of grass weeds was much poorer than the three previous seasons. The grasses germinated later than normal so they were not controlled by pre-emergence treatments. The control of dicots was also somewhat poorer than the previous seasons.

Cyanamid and 2,4-D was applied in three locations with depth of planting a factor in two places. The corn at State College was used for silage. Delayed pre-emergence applications were applied only at State College. A heavy application of dicot weed seeds were applied at State College before planting the corn. There were few dicots at Williamsport and Boalsburg but plenty of monocots.

The heavy applications of nitrogen made the grasses grow very vigorously. The 3 pound rate of 2,4-D at Boalsburg stunted the corn early in the season. The cultivation test with 1 1/2 pounds of 2,4-D in a different part of the same field injured the corn. This stunting was very evident but would not be noticed if the whole field had been treated.

Number weeds, 16 square feet (4 square feet, with 4 replications) State College, Treatments applied as the corn emerged.

Treatment	Rate per acre	No. Dicots	No. Monocots
Butyl ester	1#	44	150
	2#	9	123
	3#	3	98
Iso propyl ester	1#	64	108
	2#	13	135
	3#	8	73
Amine	1#	86	187
	2#	72	147
	3#	21	101
ACP 646	1#	38	204
	2#	33	161
	3#	24	121
XP40A	5#	80	161
	10#	22	153
	15#	11	113
Shell 130	5 gal.	80	186
	10. gal.	36	147
	15 gal.	23	162
No treatment		161	128

Yield of corn in bushels per acre, when 2,4-D was applied at planting time.

Treatment lbs. of 2,4-D	No cultivation	Williamsport Cultivated 3 times shallow	medium	deep	Boalsburg medium
0	13.9	67.4	65.5	62.6	59.8
1	16.1	70.2	72.9	70.4	62.4
2	20.3	74.4	67.6	60.4	65.2
3	21.8	69.0	69.5	65.3	46.1
Ave.		70.2	68.9	64.7	

Where the corn was cultivated, the 2,4-D and cyanamid was applied in bands behind the wheel of the planter. Therefore, the amount of nitrogen available to corn from cyanamid would be 266, 40 and 53.3 pounds of nitrogen per acre. In case of the no cultivation plots at Williamsport the 2,4-D was applied over the entire area.

Yield of corn in bushels per acre when cyanamid was applied at planting time.

Pounds of nitrogen rate over row	Available	Williamsport shallow	medium	deep	Boalsburg medium
0	0	76.8	87.7	88.6	60.0
80	26.6	89.2	87.6	79.2	61.4
120	40.0	82.3	101.6	97.6	58.3
160	53.3	80.9	85.8	80.6	50.0
Ave.		82.3	90.7	86.5	

Cultivation vs. no cultivation

In this test the plots were 4 rows wide and 100 feet long. There were six replications. The entire area except the six cultivation plots were treated with 1 1/2 pounds of 2,4-D at planting time. The 1/2 pound of 2,4-D post-emergence was applied when the corn was 18 inches high. There were relatively few weeds.

Yield of corn in bushels per acre, Boalsburg

Treatment			Yield
No 2,4-D		Cultivated 3 times	99.3
1 1/2# 2,4-D pre-emergence		"	91.7
"		No cultivation	72.4
"	1/2# 2,4-D post emergence	Cultivated 3 times	85.8
"	"	No cultivation	84.4

Preemergence Weed Control Treatments on Potatoes

J. S. Cobb
Pennsylvania State College

Test No. 1

Treatments
1 lb., 2,4-D acid per A.
2 lb.
3 lb.
15 gal. Shell 130 oil per A.
20 gal.
25 gal.
500 lb. cyanamid per A.
900 lb.
1200 lb.

Applied on Katahdins just before emergence.
Soil, sandy river bottom.
Time, 5/12/49.
No top damage resulted from any treatment.
The chief weed was nut grass. This was killed down by oil and cyanamid but recovered.
No significant differences in yield resulted.

Test No. 2

Treatments
Cyanamid 900 & 1200 lbs. per A.
Shell 130 oil 15 & 25 gal. per A.
Herbicide 1 2.5 & 5 lbs. per A.
" 2 2.5 & 5 lbs. per A.
Sinox W 1 & 2 gal. per A.
Koppers Dinitro 1 & 2 gal. per A.
XP 40 A 4 & 10 lbs. per A.
2,4-D acid 4 & 6 lbs. per A.
2,4-D Amine (Post) 1/2 & 3/4 lbs. per A.
2,4-D Ester (Post) 1/2 & 3/4 lbs. per A.

Treatments were applied in 12 inch bands across the row as the tops were emerging. This too late application resulted from waiting for the weeds and potatoes to start growth in a very dry spell of weather. Then a shower brought the tops up overnight and the treatments became almost post-emergence. The dry weather continued for a month after treatment and the weed control was very poor. Soil was a sandy loam. Some top damage resulted from the cyanamid, oil, 2,4-D acid, and dinitro treatments.

Treatments were on 12, 15 ft. rows replicated 4 times.

Shallow, medium and deep cultivations were made across each treatment. The following table shows the condition just before harvest time.

	XP - 40A			Cyanamid			Oil		
	5	10	Check	900	1200	Check	15	25	Check
Stand	100	100	100	100	95	100	100	95	100
Weeds	15	5	20	8	8	22	5	5	17

	Herbicide 1			Herbicide 2			2,4-D Acid		
	2.5	5	Check	2.5	5	Check	4	6	Check
Stand	100	98	100	100	100	100	85	67.5	100
Weeds	15	12.5	21	21	20	25	12.5	7.5	25

	2,4-D Amine			2,4-D Ester			Sinox W.		
	1/2	3/4	Check	1/2	3/4	Check	1	2	Check
Stand	100	98	100	99	99	100	100	99	100
Weeds	19	15	21	22.5	19	25	15	12.5	22.5

	Koppers Dinitro		
	1	2	Check
Stand	100	99	100
Weeds	19	14	24

Chemical Control of Wild Garlic (*Allium vineale*)

S. M. Raleigh
Pennsylvania State College

There is much confusion in the Allium genus because workers have not used scientific names. In Pennsylvania we have three species with the common name wild onion or garlic. *A. cernuum* has a flattened nodding stem. *A. canadense* has the old bulb coat strongly netted, stem leafy only near the base and under our conditions the bud bears bulblets and flowers. *A. vineale* produces hard and soft bulblets at the base and under our conditions generally bulblets on the top of the stem. These stems are leafy to or above the middle.

Under our conditions in south central Pennsylvania wild garlic starts growing early in September. Under good conditions the plant may be a foot high by cold weather. Early in the spring it starts growing again.

In 1948 wild garlic growing in pasture at 3 different locations were treated with 2,4-D ester, amine and 2,4,5-T ester early in April, while other plots were treated with the same material two weeks later. There were four replications. The material was applied at 1, 2, and 3 pounds per acre.

The 1, 2 and 3 pound rate of the ester quickly killed the plants which were above the soil. The amine and the 2,4,5-T reacted much slower. The 3 pound rate gave complete kill but required much longer time. Many plants escaped the 1 and 2 pound amine rates, especially in the middle of large clumps. The amine did not stick on the plants as well as the ester.

There was no difference in the control of wild garlic with the late and early April treatments. The white clover was only slightly injured by the early April treatments, but severely injured by the late April treatments, especially with the ester.

Dormant bulblets were not affected. By killing the soft bulblets, conditions were made more favorable for the hard bulblets to germinate in the fall. These plants were easily killed by 1 pound of ester in the spring of 1949. This fall there are very few hard bulblets which have germinated. It looks like one more treatment will give complete kill of wild garlic in these pastures.

In April 1949, 3 locations were treated with 1/2, 1 and 2 pounds of an ester and 1, 2, 3 pounds of an amine of 2, 4-D. The 1/2 pound of ester and 1 pound of the amine did not give satisfactory kills of the wild garlic. The 2 and 3 pound rate of amine killed the wild garlic much more slowly than the 1 and 2 pounds of the ester. A large number of the hard bulblets have germinated this fall and will be treated again in the spring.

Chemical Control of Quack Grass

S. M. Raleigh
Pennsylvania State College

The quack grass (Agropyron repens) plots treated August 7-9, 1948 (reported page 206 Proceedings, Northeastern States Weed Control Conference 1949) were planted to corn in the spring of 1949. There was no evidence of injury from any treatment. The fall and winter was very mild with very little freezing of the soil.

A quack grass sod which was plowed in 1948 but cultivated very little, was treated May 30 and 31, 1949. The plants were about 6 inches tall and growing rapidly. The treatments were TCA at the rate of 50, 100, and 150 pounds of TCA per acre, 12.5 and 25 pounds of Sherwin-Williams XP39A, Carbon and Carbide Experimental Herbicide No. 2, 1000 pounds ammate and 100 pounds of IPC per acre. All materials except Experimental herbicide No. 2 were applied by spraying with water at the rate of 150 gallons per acre. The XP39A and experimental herbicide No. 2 are dichloro urea compounds.

Stand quack grass fall 1949, treated May 30 and 31, 1949.

treatment	rate	Replications				ave.
XP39A	12.5	25	50	25	20	30
	25	50	80	50	60	60
Exp. H.No.2	50	75	100	100	100	94
	100	100	1000	100	100	100
Na TCA	50	80	80	80	90	83
	100	100	100	100	100	100
	150	100	100	100	100	100
Ammate	1000	90	60	90	95	84
IPC	100	25	5	25	5	15

The plots treated with TCA started to brown in a very short period of time. The 50 pound rate did not give satisfactory kill. With the other TCA treatments the majority of the plants were dead within a month after the applications. Broad leaf plants started to grow on the plots treated with the 100 pounds of TCA about August 1 and on the heavier rate about August 15.

The dichloro urea plots died very slowly. A month after treatment one could hardly tell which plots were treated. With the heavier rates the quack grass died in the second and third months after the applications.

The plots treated with 100 pounds of IPC were stunted so they did not produce seed. They were dark green in color.

BIOLOGICAL AND MECHANICAL CONTROL OF WEEDS IN TURF

Fred V. Grau
Director, United States Golf Association Green Section,
Beltsville, Maryland

A weed in turf is any plant that is not in harmony with our ideas of what the botanical composition of our turf should be, or, a weed in turf is any plant that interfers with our enjoyment of the turf.

It is pertinent to repeat these definitions because a plant which is classed as a weed on one turf area may be considered the ideal turf plant on another area. Thus bermudagrass is a weed in bent greens but in many fairways it is the basic turf grass. Dichondra is a weed in most turf but is cultivated for lawns in California. Again, bermuda is nearly the ideal turf grass over a large part of the United States but it is a noxious weed in agricultural lands in many states. These statements are presented to emphasize the fact that we need to be very specific when discussing weeds in turf.

No crop is so ideally suited for the natural control of weeds as turf. It can be made so close-growing and so densely knitted that most weeds can be controlled by mechanical and biological means. The great difficulty in these phases of weed control is that so many times we use unadapted grasses and subject them to wholly artificial and impossible conditions so that weeds are the natural and inevitable result. A good example is a fairway on a golf course which is planted to Kentucky bluegrass which then is watered to keep it green all summer. This exhausts the root reserves, rhizome development is inhibited, the turf becomes thin and weeds easily invade the open turf. Good fairway maintenance demands closer cutting than common Kentucky bluegrass can tolerate and survive. As the unadapted plants die, weeds come in. Another good example is clover or crabgrass in bent putting greens. The tendency is to slap a chemical on to kill the clover or the crabgrass. The facts of the case are that (1) the bent may be a loose open type or (2) the soil may be wholly unsuited to bent growing or (3) the watering practices may be ideal for clover and unsuited to bent, or, (4) failure to control insects and disease may have resulted in severe injury to the bent with the inevitably invasion of these weeds.

We have no quarrel with chemical weed control. It is an important factor in the production of specialized turf. It must be remembered, however, that much of the emphasis on chemical control has been necessitated by the lack of emphasis on better-adapted grasses and on improved biological and mechanical methods of control.

These represent our ideas of some of the important advances in mechanical and biological control of weeds. Let me point out that we have only begun to develop this long-range program.

1. Improved grasses for special-purpose turf. B-27 bluegrass. Selected in 1936, it will have taken 16 years to develop marketable quantities of seed. The data show that turf from B-27 seed is highly resistant to weed invasion as compared to common Kentucky bluegrass turf developed from seed stripped from undergrazed pastures. Virtually no crabgrass invades B-27 turf, whereas common bluegrass turf under identical conditions is heavily infested.

Selected strains of creeping bent, represented by Arlington (c-1), have greatly reduced weed populations on putting greens because the Arlington strain is vigorous, aggressive, highly disease resistant and drought tolerant. There are other strains which also have highly desirable characteristics.

The zoysia grasses, introduced into the United States at the turn of the century, long have proven to be so aggressive that few weeds survive even under indifferent management. We are only beginning to develop and to utilize these very important grasses. Strange as it seems, aside from the improved creeping bent grasses, there are no turf grasses on the open market today that can be called <u>improved</u> grasses from the standpoint of having been bred and developed specifically for turf purposes and for resistance to weed invasion. The field is wide open and the rewards are rich. We have sown zoysia seed into crabgrass infested soil in July and one year later the crabgrass threat was ended. The zoysia eliminated the crabrass.

2. Improved machinery is available for cultivating the soils beneath the turf cover to improve and deepen root systems, to enhance fertilizer efficiency, and to render the soil porous and more receptive to rainfall. Very few data are available on this important phase of turf management primarily because the large-scale use of efficient aerating equipment is still so new that few research men have been able to collect data. We have ample observations to indicate that a well-aerated turf is a healthier turf and, hence, more resistant to weed invasion.

3. Mechanical devices are being manufactured for attachment to mowers specifically for combing and brushing special types of turf to reduce crabgrass. We reported one home-made device in the USGA JOURNAL, Winter, 1949, which we referred to as vertical mowing. The coulters cut the crabgrass runners and largely prevented seed formation. Another device is the flexible tooth comb that is mounted on fairway mowers to roughen the turf and to raise the crabgrass runners so that they are cut off. I can testify to the effectiveness of this device on many golf course fairways across the nation.

These two mechanical devices have been neglected and still are not used sufficiently. Very few investigators are even considering research to gather data on the relative cost and effectiveness of these devices as compared to and in conjunction with chemical control.

We mentioned that the invasion of bermudagrass into bent greens is one of the serious problems in the southern part of the bent region which extends well into Texas. It is significant that, where Arlington (C-1) is one of the major grasses in the green, bermuda invasion is very slight as compared to Seaside bent.

Crabgrass, serious as it is over a large part of the United States, virtually is absent in turf of improved adapted grasses which have been fertilized according to their requirements and where insect control has been adequate. We have stated before that insect control can be considered the No. 1 approach to weed control. In this case we take our stand with all those who believe in modern chemical insect control.

2,4-D today is standard for the control of broadleaf weeds. We can not make any such statement for any chemical for crabgrass control nor do we anticipate that this will be the case in the forseeable future. We will go so far as to predict that seeds of improved turf grasses which will have the ability to eliminate crabgrass will be available before the "fool-proof" chemical for crabgrass control is developed. We venture the prediction in spite of the fact that there are many more investigators with far more funds at their disposal who are working with chemicals for crabgrass control than there are researchers working on the biological and the mechanical apporach to the problem. Our specific purpose in presenting this paper is to draw attention to the fact that there is great difficulty involved in selectively eliminating a grassy weed from a grass turf, and that mechanical and biological control deserves far more attention than they have received.

Allow me to cite a few more specific examples.

Goosegrass (Eleusine indica) is a serious pest on golf course tees, approaches, athletic fields, and other locations where the soil becomes dense and compact. It is a matter of record that, where bermudagrass and zoysia are planted in goosegrass infested soil, and intelligently managed, goosegrass is eliminated. Unfortunately, we have tried, unconsciously, to develop chemicals which will rectify mistakes in management and intelligent selection of the right grass for the right location. In many cases, correction of soil compaction by mechanical soil aeration has served to correct the basic conditions responsible for the weed invasion. Again, we can not hope to develop chemicals which will compensate for unfavorable soil conditions.

Common Kentucky bluegrass notably is susceptible to Helminthosporium leafspot which is most serious in the spring. Bluegrass turf weakened and thinned by leafspot is easy prey to crabgrass. Instead of developing chemicals designed to correct a symptom, how much better it would be to devote our energies toward developing a grass which is resistant to leafspot and, therefore, resistant to crabgrass. This we have done in developing B-27 bluegrass which, when seed is available in quantity, will completely replace common Kentucky bluegrass on the market for specialized turf where crabgrass is common in ordinary bluegrass turf.

Dallisgrass is a pest in bermudagrass turf throughout the South. Dallisgrass is a valuable pasture plant so that seed is widely distributed. Efforts designed to remove Dallisgrass selectively with chemicals have been disappointing. Little or no attention has been given to the mechanical and biological methods of control in spite of the fact that these methods have definite possibilities and patent advantages for economy and for minimum damage to the turf grasses. The seed stalks of Dallisgrass tend to be decumbent so that conventional mowing equipment is ineffective. Vertical mowing largely could overcome this difficulty and also would tend to destroy crowns of Dallisgrass.

It is a matter of record that, when turf is in good healthy condition by virtue of intelligent management and a sound feeding program, chemical weed control greatly is simplified with minimum damage to the turf grasses. It is our considered opinion, therefore, that biological and mechanical means of weed control deserve far more attention alone and in conjunction with chemical control. Among these we include:

1. Development and use of improved adapted grasses

2. Correction of soil compaction by aeration

3. Better mowing technics, especially vertical mowing

4. Improved combing or brushing of turf

5. Better knowledge of grass nutrition

6. Combinations of cool-season and warm-season perennial grasses.

BRUSH CONTROL IN CUBA

Kenneth V. Thimann[1]

Probably one of the most difficult of all woody plants to kill is the Cuban shrub Aroma marabú (Dichrostachys nutans). Introduced from East Africa in the 1870's, this plant has established itself widely in Cuba, especially in the three central provinces, and is now firmly in control of hundreds of thousands of acres of potentially valuable land. There are probably three reasons for its rapid proliferation and resistance to ordinary control. In the first place, of course, being in the tropics it has a 12-month growing season, although it does grow more slowly in the dry winter months than in the rainy summer and fall. In the second place it has (as have many other shrubs) great powers of regenerating buds from the base or crown just below ground level. When cut to ground level, it develops from basal buds to a height of six to eight feet in three months. Third, and most important, the bushes are surrounded by radially growing lateral roots, close to the surface, from which new shoots are constantly developing at distances up to many feet from the parent plant. Since these grow from a pre-established root system their growth rate is very rapid.

Our first experiments in treating these plants with 2,4-D were made in February 1947 and experiments have been made at intervals since[2]. At first these were located at the Atkins Garden in Soledad, near Cienfuegos, and later in various nearby plots of land belonging to the Compania Azucarera de Soledad.

At the beginning it was shown that the effectiveness of 2,4-D sodium salt was increased by adding 1/2% of Carbowax 1500, that plants in sun and shade were about equally affected, and that two sprayings with 0.3% aqueous solution of the salt plus Carbowax or 0.3% aqueous suspension of ester caused 87% apparent kill, as judged by appearance up to 2 months after spraying (1). In these treatments coarse sprays using about 80 gallons per acre were used. Subsequently it was found that stronger solutions such as 1% or 2%, while they caused very rapid defoliation, had less toxic effect afterwards and the treated plants ratooned from the base vigorously. About 0.5% solutions was optimal (2). This effect was probably due to too rapid loss of the leaves, so that the 2,4-D was not sufficiently absorbed.

Later experiments indicated that the ester of 2,4,5-T was somewhat less effective than that of 2,4-D, but that certain mixtures of the two were apparently more powerful than either one singly at the same total concentration (3). Arsenite, alone or mixed with 2,4-D, was quite ineffective.

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[1] Professor of Biology, Harvard University, Biological Laboratories, Cambridge 38, Massachusetts.

[2] I wish to acknowledge the cooperation, in these different series of experiments, of E. Nelson, John Torrey, Irwin Spear, and Prof. A. G. Kevorkian. My thanks are due to Mr. José de la Torre for examination of the plants, to the Compania Azucarera de Soledad for their constant and helpful cooperation, and to the Sherwin Williams Co., Havana, for support.

These experiments were made with low-volume spray nozzles using as little as 10-20 gallons per acre, mostly with 0.5% solutions of 2,4-D or 2,4,5-T ester. However, in all of this work the ultimate percentage kill, as determined after 6 months or more, was quite low. Regeneration of shoots from the base, which would take place within 10 days when the plants were simply cut off, would be inhibited completely for 10 or even 15 weeks after spraying (1), but they would often come eventually, and in any event there would often be growth of new shoots from the root system many feet away from the treated plants. For these reasons it is not possible to determine the effect in a short time. It seems likely that many reports of killing shrubs and trees with 2,4-D have been founded on too short a time of observation.

Because the universal practice in Cuba is to cut the plants to the ground about once a year, it was thought worth while to study the effect of treating the cut stumps with 2,4-D in various forms. In this work the use of gas oil instead of water as a solvent was found to give no increase in effectiveness (4). Using a paintbrush, the solution soaked quickly into the cut surface and a second application a week later was found to give increased ultimate effect. Some of the results are summarized in Table I. In experiments with foliage sprays, extraction and bioassay of parts of treated plants showed the presence of 2,4-D in the stems, but did not indicate that appreciable amounts had reached the roots (4). Therefore in experiments this summer and fall attempts have been made to introduce larger quantities of the chemical, by spraying the stumps to run off instead of painting, and by returning to foliage sprays with high gallonage(5).

In going over the data of some of these experiments it was noticed that results from plots given duplicate treatments disagreed markedly with one another in certain cases. Reexamination of the notes brought to light the fact that in these instances the amount of solution applied per plant had been markedly different. Examples of such plots are shown in Table II. In these plots the plants were fairly uniform, averaging 5 feet in height. It will be seen that there is close correlation between the volume applied per plant and the relative effect. On the other hand when the applied volumes were the same the effects agree well. It is evident that any differences between treatments are quite swamped by this effect.

Similar considerations hold for stump treatments. In our first stump treatments, with paintbrush, about 0.4 cc. of a strong solution of 2,4-D ester was applied. Using one application of 10% solution, or about 40 mg. per stump, the percentage kill after 8 months was only 13% (cf. Table I). Using two applications (80 mg.) the kill was raised to 23%. (Eight months is more than sufficient time for all regeneration to be completed; the percentage "ratooning" generally reaches constant values in about 5 months.) The best results in this series came from 30% solution, applied twice. In this case each plant received 240 mg. of chemical. The resulting kill was 44%. The effect is thus roughly proportional to the amount of chemical applied per plant.

Lastly it appears that results from foliage spraying and from stump treatment can be considered together on the same basis. In Table II the lowest quantity applied corresponds to about 240 mg. chemical and gives 30% apparent kill; the highest quantity is 450 mg. and gives 90%. These figures are of the same order as those above.

All of these and other data can thus be plotted together as in Fig. I. The data for 800 mg., in brackets, have only been read after 3-1/2 months and it is possible that some ratooning will still take place. On the whole it appears that 600-700 mg. of chemical per plant (based on 5 foot plant as standard) is needed to approach a complete kill.

A moderately overgrown pasture containing 4,000 plants per acre would thus require 3 kg. of chemical or about 2 gallons of the 40% ester. The cost of chemical is thus considerable. The cost of application must be added, but with stump treatment this becomes quite low. On the other hand the cost of cutting annually amounts of course, within 2 or 3 years, to a much greater sum.

It was mentioned above that mixtures of 2,4-D and 2,4,5-T are apparently more effective than either one alone. This has been found independently by other workers with brush in northern climates, and many manufacturers produce mixed preparations. The importance of this effect, and the optimum mixtures for Aroma marabú, are not yet clear, but the mixture will evidently allow a somewhat lower quantity of total chemical per plant, easing the above economic considerations.

In conclusion, the major area of ignorance now appears to be the penetration of the chemical into and along the root systems. This is a problem we hope to study during the coming year. The technique has been developed and has been used successfully in preliminary experiments. With this additional information one might begin to hope that the problem of eradicating tropical woody plants is at least understood.

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TABLE I

Effects of 2,4-D ester brushed on to cut surface of stumps.

Each experiment contains 50-100 stumps. July 1948.

Concentration of solution	No. of treatments	Per cent killed (after 8 months) Applied in water	Applied in oil
30%	1	38	----
	2	44	----
20%	1	27	30
	2	29*	34**
10%	1	13	14
	2	23	8*

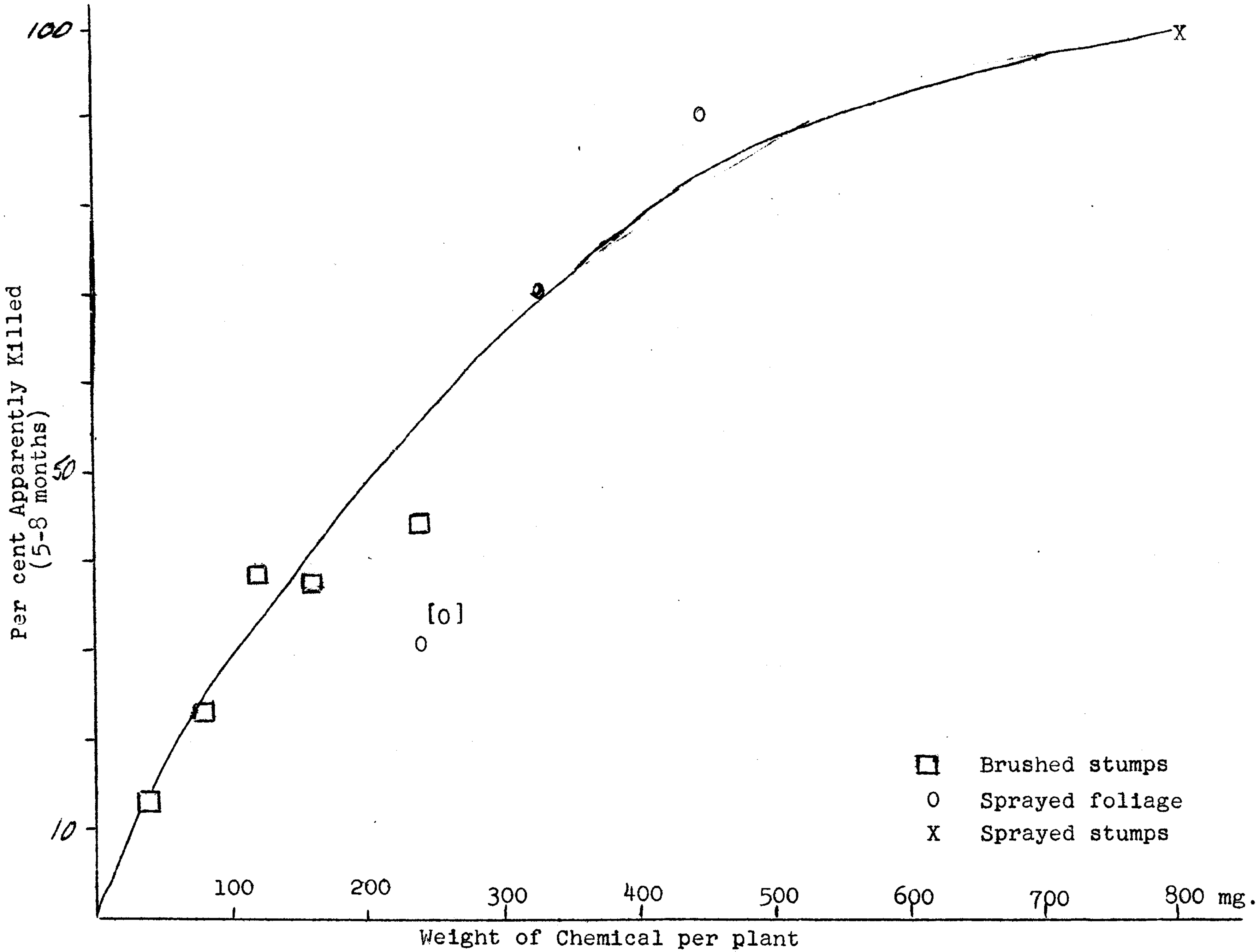
* Mean of two experiments

** Mean of three experiments

TABLE II

Duplicate Plots showing Disagreement (4, 5 and 10) and Agreement (7 and 9) related to Volume per Plant. [Concentration ca. 0.6%]

Treatment	Plot	No. of plants in plot	Gallons used	Volume per plant (Hundredths of gallons)	Per cent Apparently killed at 4 months (approx.)
4	A	88	1.5	1.70	70
	B	153	1.67	1.09	30
5	A	75	1.4	1.87	80
	B	140	1.5	1.07	30
10	A	168	3.4	2.02	90
	B	105	1.6	1.52	20
7	A	118	1.5	1.27	50
	B	141	2.0	1.42	50
9	A	130	2.3	1.79	70
	B	131	2.3	1.78	80


100
50
10
Per cent Apparently Killed
(5-8 months)
100
200
300
400
500
600
700
800 mg.
Weight of Chemical per plant
[o]
Brushed stumps
O Sprayed foliage
X Sprayed stumps

Polybor-Chlorate & Borascu for Weed Control

F. S. Spon[1]

At the 1948 Meeting of this Conference, it was the writer's privilege to present a paper and to show Kodachrome slides so as to acquaint those interested in weed control with the possibilities of a borate material. In the two years that have intervened we have not only broadened our knowledge of the use of Borascu, but we have in addition developed a new product, Polybor-Chlorate. Whearas Borascu is intended for dry applications, Polybor-Chlorate is for use as a spray or a dry application. As the time allotted to me is rather short, I feel it more desirable to only offer a brief description of these two materials and then to use the balance of the time to show you Kodachrome slides which far better illustrate some of our more recent experiences.

Borate materials contain boron which is a minor element of the soil. By applying excess quantities of Boron to the soil, we create a condition which is usually toxic to the plant life present. We generally obtained a high degree of kill of the existing growth from the initial application and often a sufficient excess boron residue remains to act on new growth from dormant seeds. Refined borax can be used but a less expensive material is Borascu which is the concentrated ore from which borax is produced. Borascu is applied to the soil as a dry granular material, either by hand or through the use of a mechanical spreader, at an average rate of 10 lbs. per 100 square feet. The Kodachromes which you will later see generally bear out our recommendation that Borascu be applied to young growths or to more advanced growth that has been closely cut or to land that has been freshly cleared or scalped. We are, of course, dependent on rainfall to dissolve the Borascu and take it down to the feeding root level. Excessive rains may sometimes leach the material too rapidly which results in faster control of deep-rooted growths but poor and more spotty control of shallow-rooted annuals. Adversely when long dry spells occur, as experienced this last year, it may be weeks before any indication of kill is noted. There is, of course, no deterioration of the Borascu because of its chemical nature, as it lays on the soil in its dry state and, therefore, too little rather than too much rain makes for better general results. Borascu is not a fast acting material, nor is it the least expensive herbicide that can be obtained, but Borascu is probably one of the most complete control herbicides available if applied properly under favorable conditions. It is, of course, easy and safe to handle, has no poison or fire hazard either during use or from residual effect, and does not necessarily require any special equipment for this application.

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[1]Pacific Coast Borax Co., Division of Borax Consolidated, Limited, New York, New York

In addition to regular Borascu, which has been so widely used, we are now making available an anhydrous form of this same concentrated ore. We call this product "Concentrated Borascu". Whereas the regular material has nearly 50% water, the concentrated product has less than 1%. As a result only 5 to 6 pounds per 100 square feet are required as against the Borascu recommendation of 10 pounds. In sections of the country where it was used during 1949 "Concentrated Borascu" proved both satisfactory and more economical. Spreading time is reduced, less material needs to be handled and the higher rail freight charges in effect to the East cover more useful material.

For some years, we have realized that a herbicide for spray use was desirable under certain conditions. Sodium Chlorate had been proven effective but was objectionable due to the attendant fire hazard. Borax was not adaptable to spray work due to its low rate of solubility. After considerable research, we developed a Polyborate which, when combined with Sodium Chlorate, appears to have great possibilities. The reaction resulting from this combination eliminates the fire danger present during the use of straight Sodium Chlorate and also removes the danger from residual deposits on the dead vegetation. The theory behind this product is that we obtain a contact kill from the Sodium Chlorate content and leave on the soil an excess boron and Sodium Chlorate residue which serves to further retard present or future growth.

Polybor-Chlorate falls into the high volume, rather than the low volume, spray class. Based on the initial experimental work we made a recommendation that 1 lb. be added to one gallon of water. Agitation is necessary in the spray equipment to accomplish solution. However, for most knapsack sprayers and for spray rigs that do not have too active an agitator, this mixture has proven satisfactory. In one case in the East, we added 2 lbs. of Polybor-Chlorate to a gallon of water when the spray rig involved had a very positive agitator and after the tank had been emptied no residue remained. Further experimental work indicates that a larger quantity of Polybor-Chlorate can be added to a smaller quantity of water and, therefore, we are able to reduce the high volume required when there is good mechanical agitation. In demonstration work this year in the East, where we were seeking as complete an original kill as possible, we have applied quantities of Polybor-Chlorate varying from 2 lbs. to 3 lbs. to an area of 100 square feet. As might be expected, Polybor-Chlorate shows a very rapid effect on the existing vegetation. Not more than 3 days has been required for the existing above ground vegetation to be knocked down. Observations made this fall of plots set out during 1949 in northeastern states indicate that the control has been complete for the full season as the result of a single spray application with little or no regrowth being visible.

By the completeness of the original kill, at rates of 2 lbs. of Polybor-Chlorate per 100 square feet, it has been indicated that possibly this material could be adapted to selective work if the quantity applied was reduced.

Preliminary Report on Atmospheric Pollen Studies

John S. Wiley and C. M. Tarzwell [1]

Atmospheric samples for determining the pollen concentration in the air are generally obtained by means of a standard pollen sampling device, as recommended by the American Academy of Allergy. This device holds a microscope slide, coated with petrolatum or glycerine jelly, which is exposed for 24 hours. The number of pollen grains per unit area of the slide are counted at 100 magnification after staining. The slide is held horizontally in the sampler between two protecting metal discs. This method of sampling has been termed the "gravity method", it being initially thought that pollen grains settle from the air upon the slide in accordance with Stoke's Law of sedimentation of spheres in still air. Because it is desired to determine the pollen concentration per unit volume of air, some workers have converted the gravity counts, expressed in grains per square centimeter or per 1.8 square centimeters of the glass slide, to a volumetric basis, expressed as grains per cubic yard of air. The rate of sedimentation, as determined by Stoke's Law, has been utilized in such conversions. Some have computed conversion factors on the basis of simultaneous sampling with the gravity device and with volumetric air samplers.

The gravity method has advantages in that it is inexpensive, has no moving parts, requires no source of power, and is easy to operate. However, it possesses the following disadvantages:

(1) Gravity counts require 24 hours and instantaneous or short-time sampling cannot be accomplished by this method.

(2) The amount of pollen on the slide may not depend entirely, or even principally, on sedimentation and therefore may not be logically converted to a volumetric count. Thus, the gravity count may not be related to the amount of pollen taken in by the breathing of allergic individuals.

The Environmental Health Center has conducted limited studies over the past ragweed season on various atmospheric samplers for determining pollen concentration. Thirteen standard pollen sampling devices were used in the Cincinnati area during the period August 8 to October 1, 1949. A few simultaneous runs were made with three volumetric samplers, air whips and gravity devices. The objectives of these experiments are:

(1) Development and checking of sampling methods for quantitative determination of ragweed pollen in the atmosphere.

(2) Determination of the drift of ragweed pollens.

(3) Determination of minimum threshold concentration of ragweed pollen in air which causes symptoms of hay fever in allergic individuals.

After making a survey of the literature, the authors did some scouting in the area to locate large areas of ragweed growth. It was observed that

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[1] Sanitary Engineer and Senior Scientist, Federal Security Agency, Public Health Service, Environmental Health Center, Cincinnati, Ohio

both giant and short ragweed were widely scattered and that, while there were local concentrations, large areas that might serve as focal points without nearby growths could not be found. Giant ragweed predominated locally in the river bottom areas along the Ohio River, Big and Little Miami Rivers, Mill Creek and many smaller creeks and ditches. Short ragweed was even more scattered and was found in vacant lots, along roadways and alleys, between curbs and sidewalks, and in other relatively denuded areas. Areas of both giant and short ragweed totalling about 40 acres were found along Mill Creek in a distance of about 1 mile along the creek and about 2½ miles from the center of the city. This seemed to be the largest concentrated growth in the metropolitan area, but complete spotting and mapping were not done.

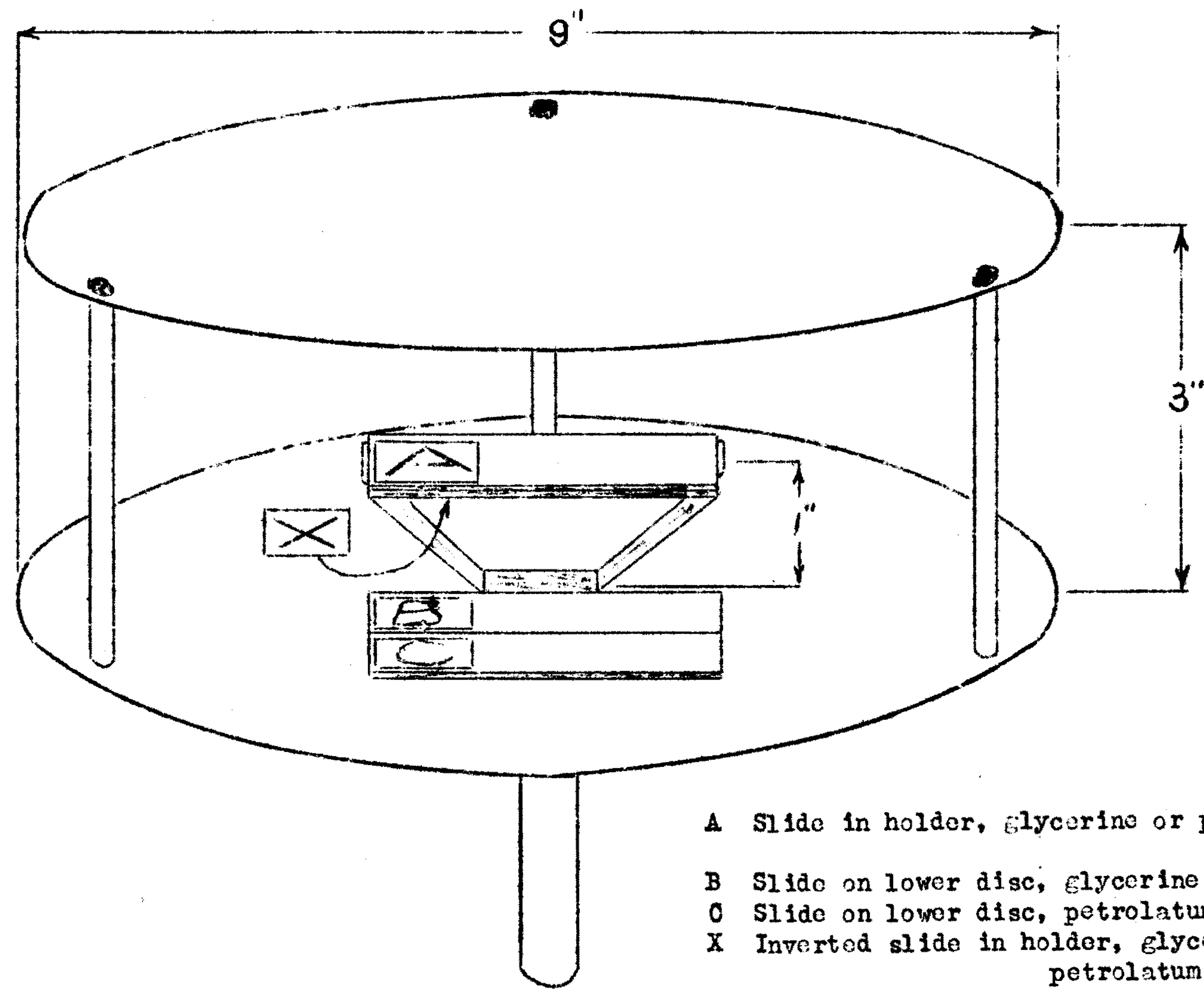
In an attempt to determine the drift of ragweed pollen under different conditions, sampling stations were located initially along two axes with the hub near the center of the Mill Creek area. Comparisons of counts at the several stations were made during the first period, August 8 to September 6. Several stations were relocated early in September when it appeared that other sources of pollen than that along Mill Creek were interfering with drift determinations. During the second period, September 6-30, stations were more widely separated to give a better indication of the pollen concentration in the entire metropolitan area, and to determine the relative amounts of pollen contributed from urban and rural areas.

Sampling by the Gravity Method

Approximately 12 stations were employed during each of the two periods of operation. Station 1 was designated as the "official station" and counts were released daily through the Cincinnati Health Department. Station 15 was serviced daily by the U. S. Weather Bureau personnel. The remaining stations had slides changed only on week days, resulting in 4 one-day counts and 1 three-day count per week. A comparison of 3-day exposure periods against 24-hour periods indicated that only 56% of the value was obtained over week-ends as against single days at the same stations, whereas counts at Station 1 had no significant difference between the same week-days and week-ends. Therefore, all counts of 3-day and a few 2-day, 4-day and 5-day exposures are omitted in the following discussion.

The standard device, slightly modified, is shown in the accompanying sketch (Figure 1). It consists of two smooth metal discs 9 inches in diameter fastened 3 inches apart by small metal rods. The head is supported by a metal rod, 30 inches or more in length, which in turn is inserted into a firm base. Coated slides are exposed in the slide-holder one inch above the bottom disc. Slides are treated with a drop of stain which is covered with a 20 mm. cover glass. Counts are made at 100 magnification so that 5 sweeps across the cover glass gives the count for 1 square centimeter. The methods of exposing the standard and experimental microscope slides are shown in Figure 1.

Slide A is in the normal position, in the center and one inch above the lower disc. Slides B and C, which were used to compare results with glycerine and petrolatum coatings and to determine the significance of the 1-inch elevation of slide A, were placed flat on the lower disc near the center. These were held in place by cellulose tape. The normal flat slide-holder was modified in a number of the samplers to a slide clip. This modification permits



A Slide in holder, glycerine or petrolatum coating
B Slide on lower disc, glycerine coating
C Slide on lower disc, petrolatum coating
X Inverted slide in holder, glycerine or petrolatum coating

FIGURE 1

POLLEN SAMPLING DEVICE SHOWING POSITION OF SLIDES two slides to be placed back-to-back, permitting the exposure of the A slide and an inverted slide, X. Counts on the X slide when compared with the standard counts should indicate the degree in which sedimentation participates. If the deposition of pollen on the slides depends entirely on sedimentation, there should be no deposition on the X slide.

The map (Figure 2) shows the location of the various sampling stations in the Cincinnati area. The following table gives the elevation of the instruments which in a number of cases is considerably greater than the ground elevation by reason of being located on building roofs:

Period I (August 8 - September 6)

Station	Elevation (ft.) Ground	Sampler
1	520	1105
2	440	620
3	530	650
4	560	680
5	480	600
6	720	745
7a and 7b	630	630
8	630	730
9a	910	910
10	820	870
11	925	1025

Period II (September 6 - September 30)

Station	Elevation (ft.) Ground	Sampler
1	520	1105
5	480	600
8	630	730
9b	920	1020
10	820	870
11	925	1025
12	910	970
13	900	900
14	890	910
15	855	895
16	980	990

Analyses of Data Obtained by Gravity Samplers

Statistical analyses have been applied to the data obtained by the gravity sampling method. Weekly average ragweed pollen counts ($gr./cm^2$) are shown in Table 1 by Stations and the average values for all stations are shown in Figure 3. Median counts for the first four sampling days were 0, 2, 0 and 2 indicating that the sampling was begun before the ragweed pollen reached a significant level for the season. Counts reached a peak on August 30 of 168 for all stations, the maximum single count being 615 at Station 11. The counts then receded until the last week in September, during which they were similar to the initial week of Period I.

Two of the stations (7a and 7b) were established 10 feet apart in order to compare the counts at one location. In a series of 9 daily exposures, the mean counts were 37.0 and 31.0 for a difference in the actual means of 6.0 gr/cm^2. The standard errors of the two means were 8.5 and 4.8, respectively, resulting in a standard error of the difference between the means of 9.8. It appears that the actual difference between the means is therefore not significant. Further, in the 9 observations, higher counts were obtained at Station 7a in 4 and at Station 7b in 5, indicating good correlation. This series was obtained using the A slides coated with glycerine jelly to which had been added a methyl green stain.

Comparisons were next made between counts from slides exposed side by side on the bottom disc of the device, one coated with glycerine jelly (B slide) and one with petrolatum (C slide). Prior to analysis, however, it was noted

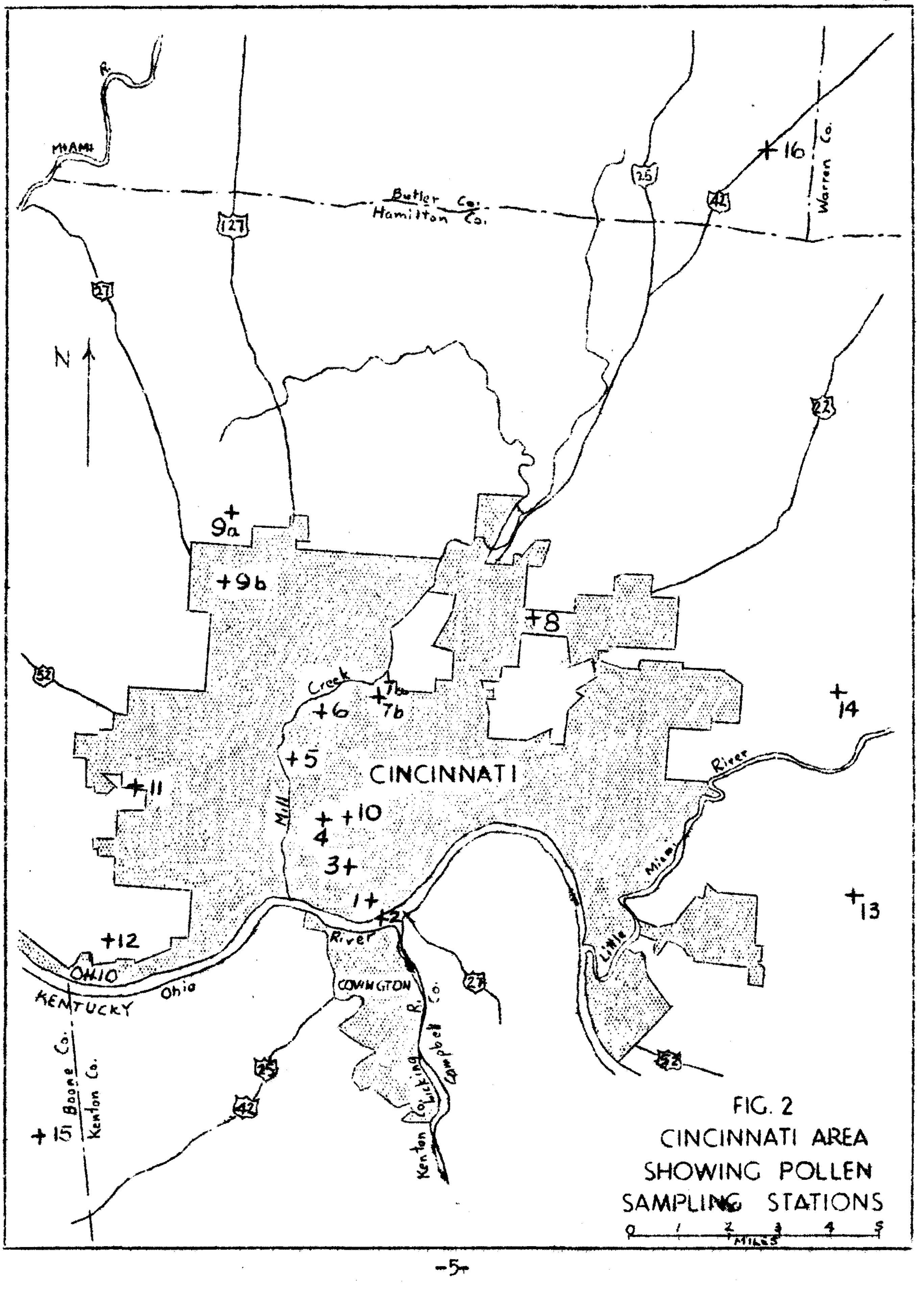


FIG. 2
CINCINNATI AREA
SHOWING POLLEN
SAMPLING STATIONS

Table 1
RAGWEED POLLEN COUNTS BY WEEKS
Daily Average of Each Station (gr./cm²)

Period I

Week (1949)	STATIONS												Avg.
	1	2	3	4	5	6	7a	7b	8	9a	10	11	
Aug. 8-12	0.3	2.8	1.0	2.3	10.5	5.5	3.0	-	-	-	1.3	-	3.4
Aug. 15-19	30.5	27.3	17.0	26.0	33.0	25.8	8.8	14.5	42.5	-	18.5	-	23.8
Aug. 22-26	79.8	48.5	43.8	53.0	56.8	54.5	27.5	30.5	62.3	41.5	61.8	87.0	53.9
Aug. 29-Sept. 2	167	174	160	118	107	131	60	47	108	80	203	389	139
Grand Avg.	69.4	55.8	48.4	42.4	48.2	54.3	29.8	33.7	76.7	60.6	66.7	216.3	60.8

Period II

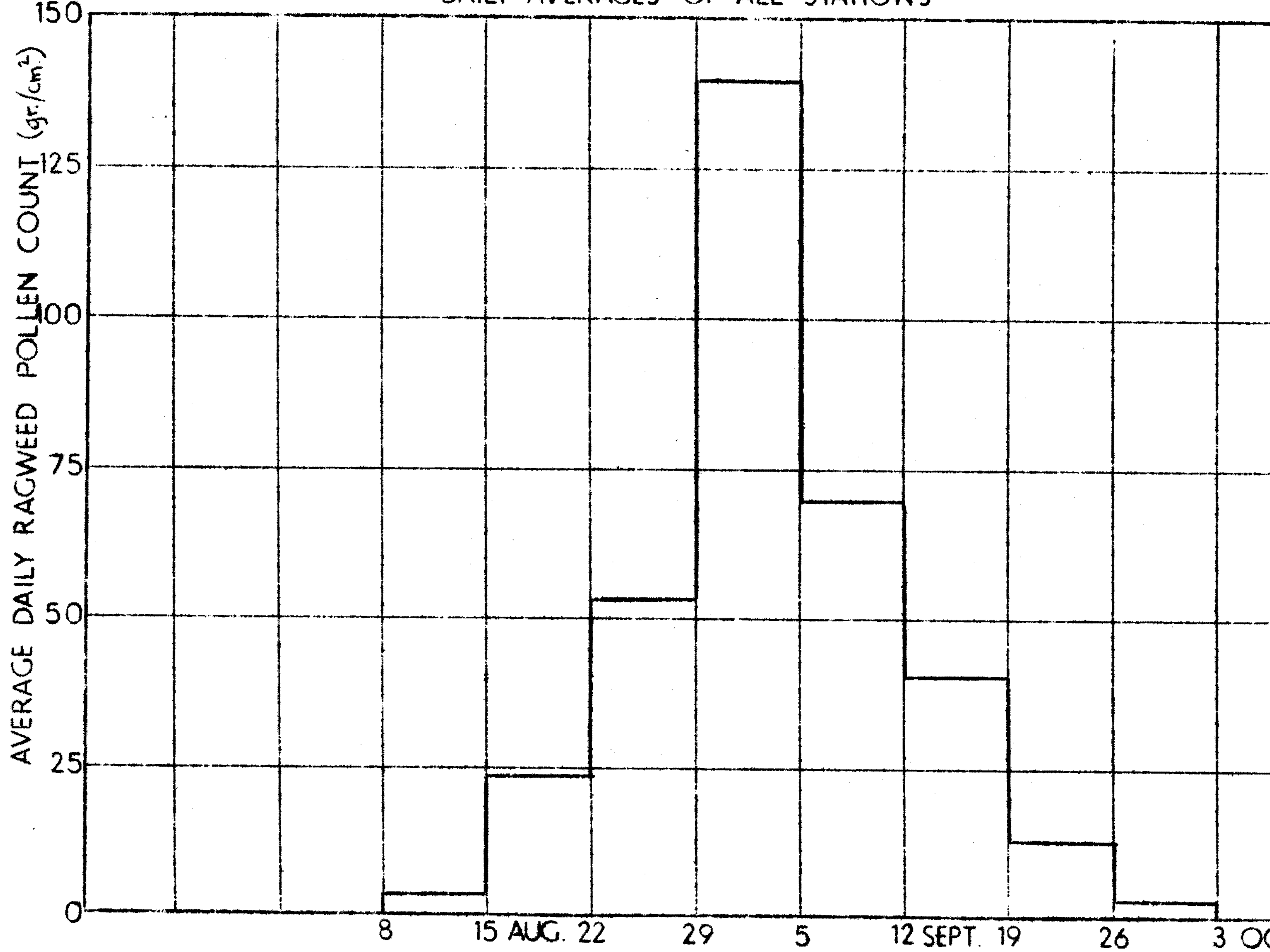
Week (1949)	STATIONS												Avg.
	1	5	8	9b	10	11	12	13	14	15	16		
Sept. 5-9	91	81	36	63	34	105	111	52	29	75	36		69.8
Sept. 12-16	41	40	27	21	51	76	30	7.0	16.0	98	28		41.1
Sept. 19-23	12.0	12.8	5.5	14.5	24.3	26.0	17.5	4.5	2.3	12.3	5.5		12.7
Sept. 26-30	2.8	1.7	3.3	-	4.0	2.0	4.5	0.8	2.3	2.5	4.3		2.9
Grand Avg.	33.1	32.6	16.7	33.6	27.8	60.4	36.0	10.9	6.3	46.2	14.5		28.9

that on two days rain, sufficient to splatter and wash off most of the glycerine jelly, occurred. This washing affected the glycerine-coated slides to a much greater extent than the petrolatum - coated slides. For the two days (Sept. 1 and Sept. 4) the mean counts were: B-81.5 and C-201.5 or a ratio B/C of 0.403. Omitting these two days and comparing the B and C counts for the remaining 18 days of the experiment, results were:

Mean daily pollen count (gr/cm²):
Glycerine-coated slides (B): 153.5; Petrolatum-coated slides (C): 120.4
Ratio B/C: 1.275; Standard error of difference of Means: 43.9
Actual difference of means: 33.1

Since the actual difference of the means is less than one standard error of the difference, the result is only slightly significant. However, of the 18 results, 12 were higher on glycerine slides and only 6 on petrolatum slides. Also, of the 18 days, rain occurred on 10 during which counts were higher on glycerine slides on 6 days. Although rain occurred on a number of days, it apparently did not wash the glycerine off unless it occurred in such a way that it was driven under the protecting disc to splatter the slides. On the basis of limited data, it is concluded that glycerine-coated slides may collect more ragweed pollen than vaseline-coated slides by 20 to 30%. On 2 days out of 12, however, rain which occurred was sufficiently splattering to reduce the counts on glycerine-coated slides to less than half that on petrolatum-coated slides. It was materially easier to count the glycerine slides (in comparison to petrolatum slides) because the pollen grains had less halation and were more readily stained.

FIG. 3. RAGWEED POLLEN COUNT BY WEEKS, CINCINNATI AREA, 1949
DAILY AVERAGES OF ALL STATIONS



Counts were next compared on slides with the same coatings but with one slide in the standard holder (A) and one on the bottom plate (B) or (C). Comparing A and B slides, both coated with glycerine jelly, including methyl green stain, the results were:

Mean ragweed pollen counts (gr/cm^2): A-102.8; B-136.7
Standard error of difference of means: 37.2; Actual difference of means: 33.9

The actual difference would be expected to occur about 36% of the time due to chance. Of 25 pairs of samples, it may be significant that 20 counts on B slides were greater than A and only 5 on A slides greater than B.

In a similar experiment using petrolatum-coated slides (A and C) results were:

Mean ragweed pollen counts (gr/cm^2): A-109.5: C-141.2
Standard error of difference of means: 31.4; Actual difference of means: 31.7

The difference occurring would be expected to occur about 31% of the time due to chance. In the 15 pairs of samples, 11 C counts were greater than corresponding A counts while only 4 A counts were greater than corresponding C counts. It is concluded, therefore, that there is a slightly significant difference in counts on slides placed in the standard holder and on the lower disc, results on the latter slides being larger. This has been confirmed by Durham(1) and would be expected because there is less protection for the slides resting flat on the lower disc.

Face-up (A) and inverted (X) slides were than compared using the same coatings and holding the two slides in the clip holders of the same instruments. Eight observations, each consisting of the average results from two devices, were made with glycerine jelly as the coating medium:

Mean ragweed pollen counts ($gr./cm^2$): A - 33.1; X - 15.3; Ratio A/X - 2.16.
Standard error of difference of means: 9.0; Actual difference of means: 18.8

The actual difference obtained would be expected to occur only about 3.5% of the time due to chance alone.

With 54 station-days, averaged for counts on 26 separate days, using petrolatum as the coating medium, results were:

Mean ragweed pollen counts (gr/cm^2): A - 37.5; X - 15.2; Ratio A/X - 2.47
Standard error of difference of means: 9.11 Actual difference of means: 22.3

The difference occurring would be expected to occur only 1.4% of the time due to chance. It is concluded that there is a significant difference in pollen counts on inverted slides as compared to slides installed in the regular manner. The interesting fact, however, is that appreciable counts were obtained on inverted slides and, on seven of 34 days the counts equaled or exceeded the standard counts. The mean values for the inverted slides were about 41 and 46% of the standard slides during the two experimental periods when counts on the A slides were approximately 35 gr/cm^2. This indicates that sedimentation of pollen grains on the standard slides may be responsible for not more than

50 to 60% of the amount actually deposited. It appears further that this conclusion places more emphasis on the impingement of particles on the coated slides due to wind or air current action than has been realized in the past. Further, it appears that the conversion of gravity counts to a volumetric basis by means of Stokes' Law alone is not warranted.

Correlation of Gravity Counts with Weather Observations and Elevation

Weather data, secured from the U. S. Weather Bureau, included air temperature, relative humidity, rainfall, barometric pressure, average and maximum daily wind velocities and directions, and per cent sunshine. Some of the data is shown graphically in Figure 4. Some of these, in addition to station elevation, have been set up on a daily basis as independent variables for comparison with ragweed pollen counts as dependent variables in order to determine their correlation. For wind directions and velocities, the readings at the Weather Bureau Station at Greater Cincinnati Airport appeared to be more representative of the general prevalence than those at the Post Office Station in Cincinnati. For other observations the Post Office Station readings were used because of the central location with respect to the pollen sampling stations.

(a) Elevation: Average ragweed pollen counts were plotted against elevations for each of the stations operating during Period I (Figure 5). There appears to be a general trend toward larger counts with higher elevations. The correlation coefficient was computed to be 0.570 indicating fair correlation with the limited data at hand. To test this further, samples were collected at three elevations at one point where a television tower was located (Station 10) atop a hill. Ground elevation at the station was 820 feet above mean sea level. Elevations and counts at the three points were as follows for the period September 19 to 30:

Station Number	Elevation-Feet Above: Mean Sea Level	Ground	Number of Observations	Average Ragweed Pollen Count (gr/cm^2)
10a*	870	50	8	14.1
10b	970	150	8	16.0
10c	1,120	300	8	13.6

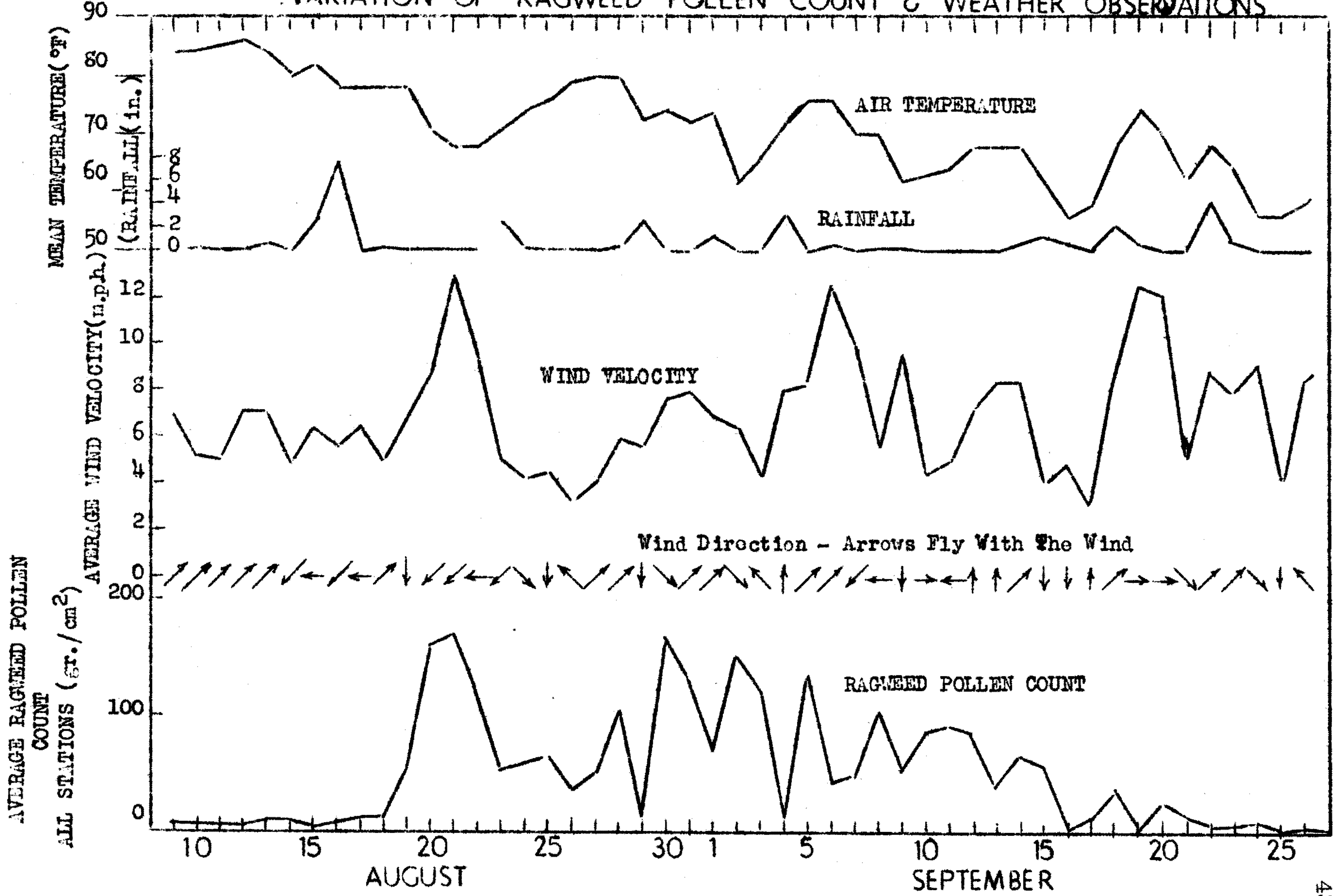
* This station designated as No. 10 in other comparisons.

The above experiment was performed at the end of the ragweed pollen season. Results are believed to be insufficient and the pollen counts too low to give any indication of the trend. It was observed by the tower climber that winds appeared to be highest in intensity at the 150-ft. station, although no wind measurements were made. It is believed that any correlation existing between elevations and gravity counts in the Cincinnati area may be caused by:

(1) Greater wind velocities on hilltops than in valleys resulting in greater impingement of pollen on the coated slides.

(2) Sources of ragweed pollen in rural areas being of greater influence than local sources.

FIGURE 4
VARIATION OF RAGWEED POLLEN COUNT & WEATHER OBSERVATIONS



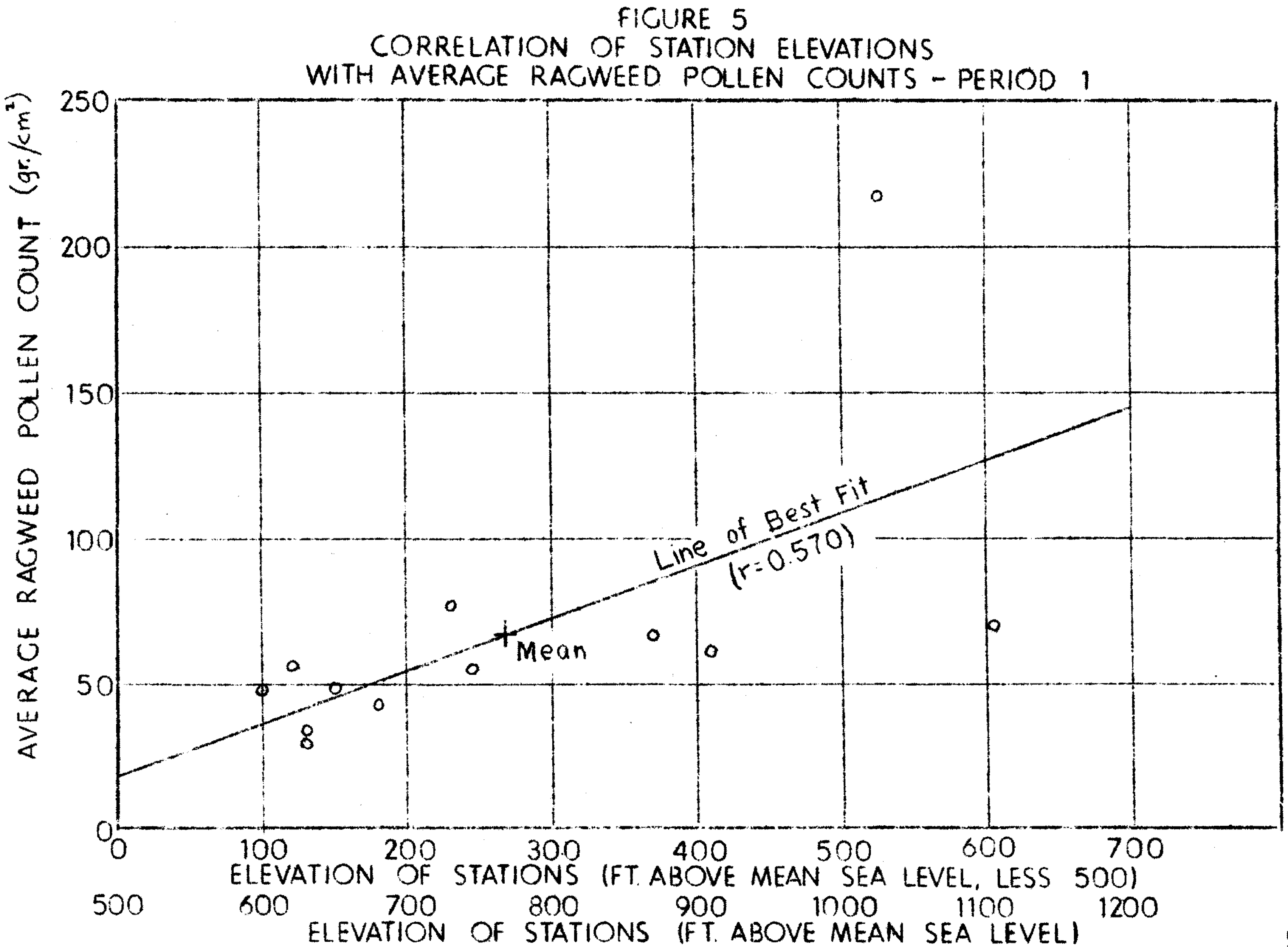


FIGURE 5
CORRELATION OF STATION ELEVATIONS
WITH AVERAGE RAGWEED POLLEN COUNTS - PERIOD 1
AVERAGE RAGWEED POLLEN COUNT (gr./cm²)
250
200
150
100
50
0
Line of Best Fit
(r=0.570)
Mean
0
100
200
300
400
500
600
700
ELEVATION OF STATIONS (FT. ABOVE MEAN SEA LEVEL, LESS 500)
500
600
700
800
900
1000
1100
1200
ELEVATION OF STATIONS (FT. ABOVE MEAN SEA LEVEL)

Further experiments are needed before definite conclusions may be drawn.

(b) Rainfall: Considering only those days in which rain fell in greater than trace amounts, the correlation coefficient was determined for daily rainfall plotted against average daily ragweed pollen counts for all stations (Figure 6). A negative slope for the line of best fit was obtained. This was expected since it indicates a decrease in pollen counts with an increase in rainfall. The correlation coefficient was -0.709, indicating fair correlation of the data. Rainfall may influence gravity counts in several ways:

(1) By limiting ragweed flowers in discharging pollen into the air.
(2) By washing out pollen already in the air.
(3) By washing the coating together with any deposited particles from the coated glass slides of the sampler.

The latter two indications appear to be of lesser importance than the first, except in the case of hard, driving rains.

(c) Wind Velocity: A comparison of the wind velocities with gravity counts for Period I has been made (Figure 7). An increase in pollen counts with an increase in wind velocity is indicated. The coefficient of correlation is 0.678, a fair value. To test the gravity sampler, two samplers were established 30 feet apart in a line perpendicular to the wind direction. Coated slides were exposed for 24 hours simultaneously on September 14-15. One device was operated normally. The second had a 16-inch fan operating at "high" speed, three feet from the sampler and facing towards the device at the same level. Ragweed pollen counts ($gr./cm^2$) were:

No. 1 - 27; No. 2 (with fan) - 183. This indicated a pollen count of approximately 7 times that of the standard device as a result of increased wind velocity.

Gravity counts may increase with wind velocity due to:

(1) Greater impingement effect on the coated slides.
(2) "Batch" release of pollen by the plants.

Gravity samplers may therefore give erroneous results depending upon the wind velocity.

(3) Wind Direction: Few indications may be obtained from the limited data obtained during the present survey. During the season of heaviest pollen production, August 19 - September 15, the wind was quite changeable in direction. Daily observations of prevailing wind direction did not always correspond to those of the direction of the maximum 5-minute speed. During Periods I and II, there were 19 and 9 days of observation, respectively, with the following prevailing wind direction distribution:

FIGURE 6
CORRELATION OF DAILY RAINFALL WITH
AVERAGE DAILY RAGWEED POLLEN COUNTS - ALL STATIONS

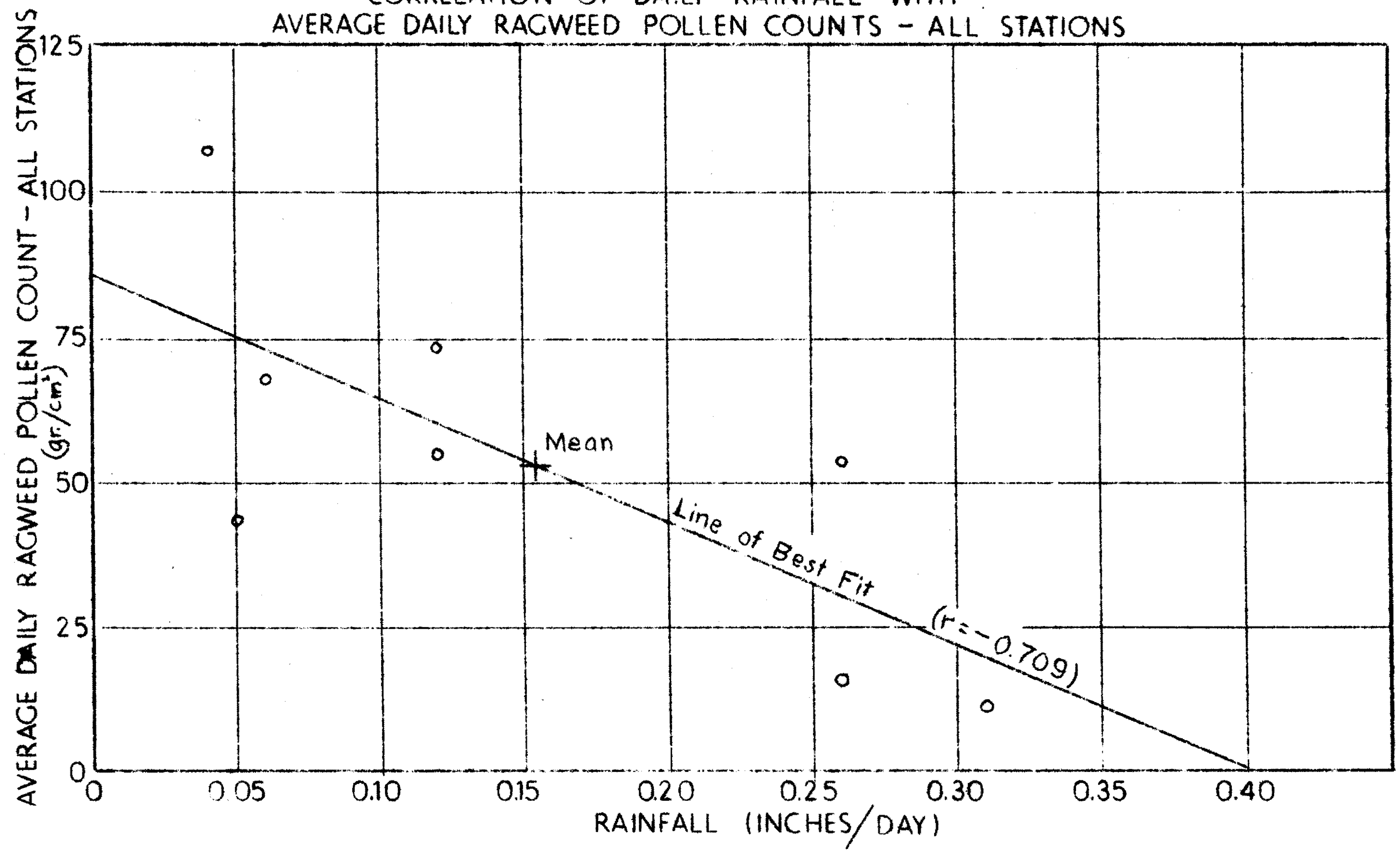
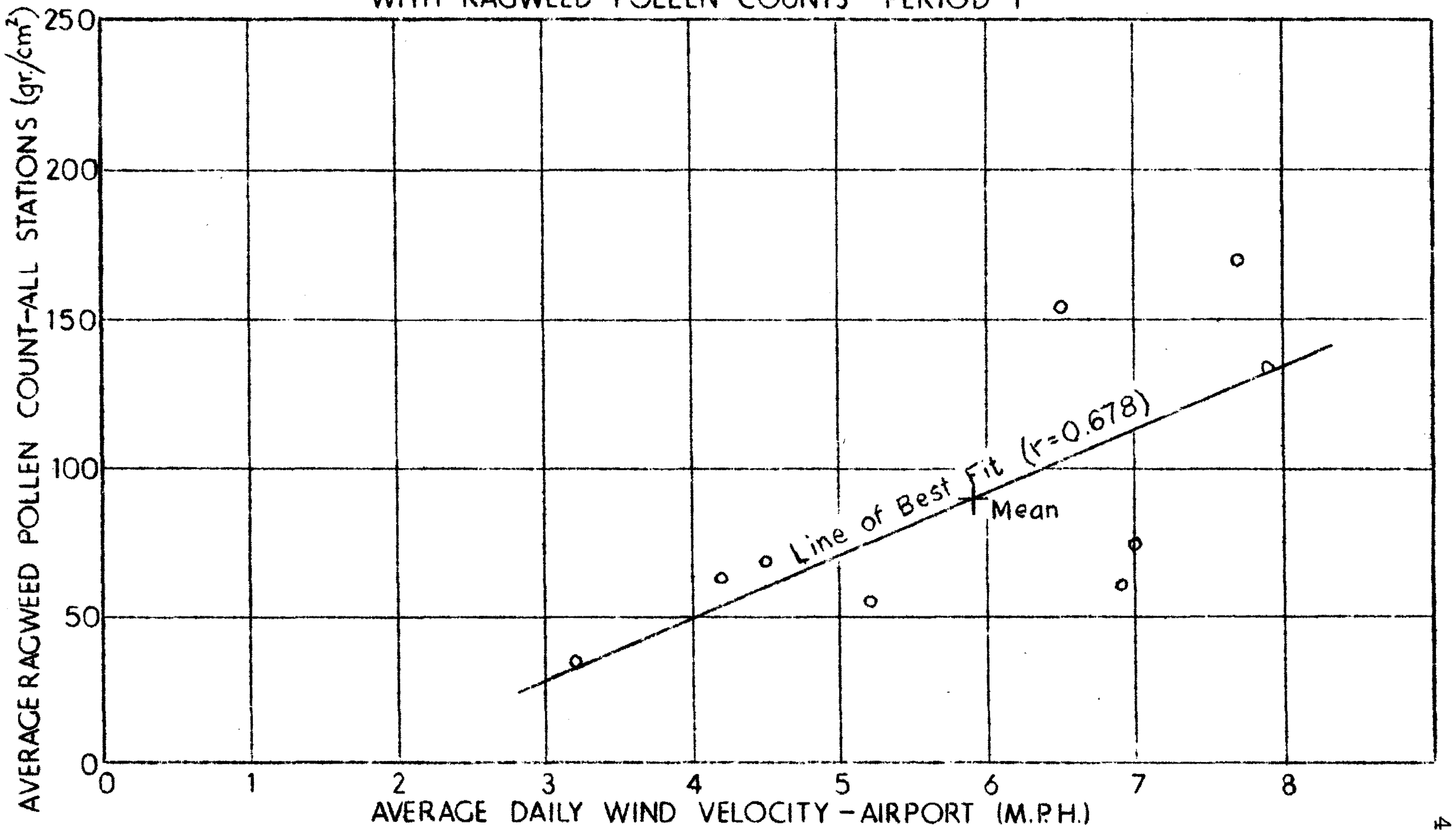


FIGURE 7

CORRELATION OF DAILY AVERAGE WIND VELOCITY WITH RAGWEED POLLEN COUNTS - PERIOD 1



Prevailing Wind Direction	Number of Days Occurring:	
	Period I	Period II
Northwest	3	0
West	0	1
Southwest	6	1
South	1	2
Southeast	2	0
East	0	2
Northeast	4	1
North	3	2
Total	19	9

In a few instances, it appeared that local sources of ragweed pollen predominated and descending counts were obtained down-wind from the station of highest value. In other instances, it appeared that sources outside of the sampling area predominated but local sources apparently influenced any calculations that might be made as to the decrease in pollen concentration with distance from the source. While wind direction greatly changed the pollen counts at the various stations, additional data are required on this point before definite conclusions can be drawn. The provision of wind direction and velocity indicators at each station is desirable if accurate interpretations are to be made.

(c) Other Weather Factors: No significant correlation was found between gravity counts and the following:
(1) Air temperature, (2) Per cent sunshine, (3) Relative humidity and (4) Barometric pressure, although these factors may be fairly important in the release and dissemination of ragweed pollen.

Sampling with Volumetric Devices

Three volumetric sampling devices were operated simultaneously with a gravity sampler for comparison. The standard Greenburg-Smith impinger is normally used for the collection of atmospheric particulate matter. Collection was made at 1 cu. ft./min. in 75 ml. of an alcohol-water mixture. Counts were made in a Sedgwick-Rafter counting cell with the aid of a Whipple disc. The electrostatic dust and fume precipitator is normally used for the collection of air samples containing fine dust or fumes. It operates at 3 cu. ft./min., the particles being attracted to the electrodes by a potential of about 12,000 volts. The inner electrode and the outer tube were washed with alcohol and the washings made up to 75 ml. Counts were then made as with impinger samples. The electrostatic bacterial air sampler was designed to collect samples of air-borne bacteria in two Petri dishes containing media for their growth and direct counting of colonies. It draws air through two ports at a rate of 1 cu. ft./min. total. One dish rests on a negative electrode and the other on a positive electrode, metal funnel-shaped electrodes of opposite charges being above the two dishes. A potential of about 7,000 volts is applied. For pollen sampling, the Petri dish bottoms were coated with glycerine jelly containing stain. Counts were made directly as with the gravity slide method except that they are computed for the entire area of the two dishes and converted to a volumetric basis.

Six runs were made as indicated in Table 2, the length of run varying from 1/2 to 7 hours. While the three volumetric samplers are each reported to be nearly 100 per cent efficient in collecting particles of a size smaller than ragweed pollen, it appears that a significantly greater pollen count per cubic foot of air was obtained by the electrostatic bacterial air sampler than by either of the other two devices. Further conclusions appear to be unwarranted on the basis of the limited data obtained to date. The gravity samples bore no constant ratio to any of the volumetric samples.

Table 2
Comparison of Volumetric and Gravity Sampling Devices

Date (1949)	Starting Time	Hours Run	Location	Ragweed Pollen Counts Impinger (gr./cu.ft.)	Elec. Precipitator (gr./cu.ft.)	Bacterial Sampler (gr./cu.ft.)	Gravity Slide (gr./sq. cm.)
Aug. 25	11:46AM	1/2	HydePark	40.0	16.7	65.5	0
Aug. 26	10:12AM	2	Clifton	15.0	27.7	39.8	7
Aug. 31	2:14PM	2	EHC Roof	12.5	47.9	68.9	12
Sept. 1	8:40AM	7	EHC Roof	45.5	83.6	135.	69
Sept. 2	11:00AM	2	EHC Roof	35.6	37.3	48.8	19
Sept. 13	9:50AM	2	EHC Roof	30.4	9.0	67.3	8
Average		2.6		29.8	37.0	70.9	19.2

Several short simultaneous runs were made with two air whips. Results are shown in the following table:

Date	Location	Starting Time	Minutes Run	Ragweed Pollen Counts (gr/cu.ft.) Air Whip #1	Air Whip #2
Aug. 25	Hyde Park	11:00 AM	2	4.9	0.24
Aug. 25	Hyde Park	11:05 AM	2	1.6	11.4
Aug. 26	Clifton	11:00 AM	5	9.3	22.0
Aug. 26	Clifton	12:00 N	5	7.0	8.2

Because of the wide variation in counts obtained by the two air whips, it appears that this instrument is not useful for exact quantitative counts. The air whip may have application in determining relative concentrations of pollen or in qualitative sampling of air-borne pollens and spores.

Conclusions

The above experiments are quite limited and further observations are needed before final conclusions may be drawn. However, the following tendencies may be summarized on the basis of the experiments:

Gravity Sampling:

(1) Counts at two points 10 feet apart showed no significant difference of the means.

(2) Slides coated with glycerine jelly may show slightly greater counts than those coated with petrolatum, except when driving rains occur. Glycerine-coated slides appear to be easier to count than petrolatum-coated slides.

(3) Counts on slides exposed flat on the botton disc of the gravity sampler appeared to be slightly greater than those in the slide holder one inch above the botton disc.

(4) Standard slides collected an average of 2 to 2½ times as much pollen as inverted slides in the same holders. However, the count on upside-down slides was appreciable and indicates that sedimentation of pollen is not the sole method of collection by coated slides.

(5) Three-day slide exposures gave results of only about half the amount expected as compared to 3 single-day exposures. Average values varied from 1/4 to nearly 1.

(6) There appeared to be fair direct correlation of gravity counts with elevation and wind velocity and inverse correlation with rainfall. Little or no correlation was indicated with counts and air temperature, per cent sunshine, relative humidity, or barometric pressure, although these factors may be fairly important in the release and dissemination of ragweed pollen.

Volumetric Sampling:

(1) Of the three volumetric samplers used under simultaneous operation, the electrostatic bacterial air sampler gave significantly higher amounts of ragweed pollen per unit of air.

(2) Gravity slide counts bore no constant ratio to any of the volumetric counts.

The data indicate that gravity counts should not be converted to volumetric counts and that impingement of pollen due to action of the wind and air currents is an important factor in the amount of pollen deposited on the slides.

REFERENCE

(1) Durham, O. C. - The Volumetric Incidence of Atmospheric Allergens IV. A Proposed Standard Method of Gravity Sampling, Counting, and Volumetric Interpolation of Results J Allergy, 17:79 March, 1946

REPORT OF THE COORDINATING COMMITTEE OF THE N. E. W. C. C. FOR 1950

The following discussion and information has been prepared in the light of the best information available at the time of the 1950 meeting of the committee. Since numerous factors contribute to the success or failure of an herbicidal application nothing in this report should be taken as conflicting with or supplanting state and local recommendations. It is the policy of this committee to make no recommendations but to designate which materials and methods are generally agreed upon so that the various states can have some guidance in making their own recommendations. Problems are listed as needing work in the sense that either too little is known or the coverage in area of the work has been too restricted.

The primary purpose of this report is to point out, for the benefit of research people, areas in which agreement is present and more importantly, areas in which more research is needed. Others may find these items of interest, but the fact that this report has been prepared by research people for the use of research people must be kept in mind when reading the various statements herein.

TURF

Agreement --

1. 2,4-D plus adequate fertilization will control many of the broadleaf weeds in turf.

2. Phenyl mercury acetate can be used to control crabgrass.

Problems needing more work --

Use of potassium cyanate with wetting agents to control crabgrass.

PASTURES

Agreement --

2,4-D plus adequate fertilization will control many pasture weeds.

Problems needing more work --

1. Methods of control of the following specific weeds: milkweed, yellow rocket, horse nettle, canada thistle, wild onion and garlic.

2. Brush control in pastures. In this connection the use of herbicides on plants poisonous to livestock should be considered from the angle that wilted plants are sometimes eaten by live-

stock even though the actively growing plant is not palatable. Thus plants like chokecherry would attract animals after spraying and cause death.

FIELD CORN

Agreement --

1. Preemergence application of 1-1/2 pounds of 2,4-D acid equivalent except in soils lighter than a sandy loam.

2. Postemergence application of 1/4 to 1/2 pound of 2,4-D acud equivalent anytime after emergence until corn is 12 inches high.

Problems needing more work --

1. Use of granular cyanamid for preemergence treatment on soils lighter than a sandy loam.

2. Use of dinitros for postemergence application.

3. Response of different hybrids to 2,4-D.

4. Basic research on cultivation and preemergence combinations.

SMALL GRAINS

Agreement --

1. Use of 2,4-D at 1/4 to 1/2 pound acid equivalent per acre after stooling but before jointing except when grains seeded to legumes.

2. Spot treat for canada thistle at 1/2 pound to 1 pound 2,4-D acid equivalent per acre at above time. Retreat after harvest at 1 pound per acre.

Problems needing more work --

1. Fall treatments of fall seeded grain.

2. Control of weeds in grain seeded to legumes.

3. Use of dinitros in selective formulations.

POTATOES

Agreement --

Nothing available that could be agreed upon for potatoes.

Problems needing more work --

1. Preemergence application of such materials as Dinitros in general killing formulation, sodium pentachlorophenate, sodium pentachlorophenate plus oil, pentachlorophenol, and 2,4-D.

2. Postemergence applications of various chemicals.

3. Combining herbicides with other production factors such as planting rate, irrigation and fertilization.

4. Combination of herbicides and cultivation.

SWEET CORN

Agreement --

Use of 2,4-D at 1/3 to 1/2 pounds 2,4-D acid equivalent per acre as application at emergence or until the time corn is 6 inches high.

Problems needing more work --

1. Influence of 2,4-D on nutritive value of corn.

2. Influence of 2,4-D on susceptibility of corn to smuts and rootrots.

3. Use of sodium pentachlorophenate in corn at planting time.

4. Use of heavier applications of 2,4-D at planting time.

5. Combination of chemical weed control and cultivation.

PEAS FOR PROCESSING

Agreement --

1. Use of dinitros in selective formulations.

2. Use of potassium cyanate.

3. Use of dusting grade cyanamide.

Problems needing more work --

1. Use of 2,4-D on peas.

2. Use of salt spray in peas where lamb's quarters are no problem.

3. Relation of chemicals to nutritive value of peas and to rate of maturity of crops.

4. Use of granular cyanamid.

CARROT FAMILY

Agreement --

Stoddard Solvent at 80 to 100 gallons per acre applied on cool, still, cloudy day when leaves are dry. Can be used from the time one true leaf develops until one month before harvest. This applies to carrots. Parsnips, parsly, dill, fennel, coriander, caraway, and celeriac are somewhat more sensitive but Stoddards Solvent can still be used. With celery material cannot be applied after two true leaves are found.

Problems needing more work --

1. Influence of various constituents of oil on amount of injury to crop.

2. Influence of weather conditions at time of application on amount of injury.

3. Effect of cultivation and chemical treatment on yield and quality of crop.

ASPARAGUS

Agreement --

1. Granular cyanamid at rates in excess of 350 pounds per acre in band 18 inches wide over row early in season.

2. Dusting grade cyanamid at 100 pounds per acre when weeds are wet.

Problems needing more work --

1. Use of 2,4-D and effect on longevity of beds.

2. Use of other chemicals such as sodium pentachlorophenate, and potassium cyanate.

ONIONS

Agreement --

1. Preemergence application of dusting grade cyanamid at 75 to 150 pounds per acre when weeds are wet.

2. Potassium cyanate as selective spray after onions are up and when weeds are small and dry.

Problems needing more work --

1. Use of other materials such as sulphuric acid and pentachlorophenol.

2. Influence of weather conditions at time of application on results of herbicidal applications.

BEETS

Agreement --

No materials available that could be agreed upon.

Problems needing more work --

1. Preemergence application of Stoddard Solvent.

2. Other materials for preemergence use.

3. Salt spray for selective use.

OTHER VEGETABLES NOT COVERED ABOVE

Agreement --

No materials available that could be agreed upon.

Problems needing more work --

1. Chemicals that will be selective for these crops.

2. Possibility of selective action not with foliage sprays but selectivity at seedling stage.

3. Difficulties in seeding when land is prepared in advance and allowed to stand until weeds grow.

4. Chemicals or combination of chemicals which when applied at planting time would destroy weed seedlings with no injury to crop seedlings.

5. Trichloroacetate materials as soil treatment for crucifers.

6. New approach to application of spray such as stem application as used in cotton.

7. Further work on old type preemergence ideas. Some vegetable growers successfully practice this on commercial scale.

CRANBERRIES

.greement --

Because the results from only one state in the Northeast were available at this meeting, nothing can be listed as generally agreeable.

ʾroblems needing more work --

1. Cultural practices which will help to control weeds such as providing adequate drainage, stimulate cranberry vine growth, late holding of winter flood.

2. Use of kerosene at 400 to 800 gallons per acre early in season for many grasses, sedges and rushes.

3. Use of Stoddard Solvent during semi-dormant period for cranberry vines for control of asters and brambles.

4. Use of ferrous sulphate at high rates for selective killing of many weeds.

5. Paradichlorobenzene under sand at rate of 1200 pounds per acre for selective kill of poison ivy, chokeberry and wild bean.

6. Copper sulphate for nut-grass and also for control of green algae and diatoms in winter flood.

7. Ferric sulphate for selective spot treatments.

8. Search for less expensive methods of weed control.

9. Methods for control of Smilax.

BLUEBERRIES

Agreement --

Nothing that could be agreed upon.

Problems needing more work --

1. Treating cut stumps of gray birch with 2,4,5-T.

2. 2,4-D for selective control of sweet fern.

3. 2,4,5-T for selective control of bayberry, sumac and hardhack.

4. Fall spray of Stoddard Solvent for low spear grass, carpetweed, and purslane.

5. Dinitros in high bush plantings as dormant spray.

6. Stump control in general.

7. Witch grass control.

BRAMBLE FRUITS

Agreement --

Nothing that could be agreed upon.

Problems needing more work --

1. 2,4-D salts up to 1-1/2 pounds acid equivalent per acre protecting the young canes.

2. Dinitros for grass control.

3. Use of trichloroacetate materials for grass control.

4. Pentachlorophenol for selective spraying.

STRAWBERRIES

Agreement --

Nothing that could be agreed upon.

Problems needing more work --

1. 2,4-D up to 1 pound acid equivalent per acre at anytime except during fruiting season.

2. Timing of 2,4-D application and effect on fruiting.

3. Use of other chemicals such as sodium 2,4 dichlorophenoxyethyl sulphate (Exp. Herbicide No. 1, Carbide & Carbon Chemical Co.), Dinitros, potassium cyanate.

4. Chickweed control by such chemicals as isopropyl carbamate, and potassium cyanate.

GRAPES

Agreement --

Nothing that could be agreed upon.

Problems needing more work--

1. Dinitros as directed sprays.

2. Other chemicals which grapes will tolerate.

5. Weed control to reduce hoeing in nursery stock by directional sprays of oils, potassium cyanate, sodium pentachlorophenate and other chemicals.

6. Control of weeds in ornamental plantings so that a neat and pleasing appearance is maintained.

BRUSH CONTROL

Agreement --

1. Chemical control of brush requires the application of enough herbicide in large enough volume to thoroughly wet the foliage and the bark.

2. Chemicals used in brush control are: ammonium sulphamate, and the growth regulators 2,4-D and 2,4,5-T.

3. For specific cases other chemicals are useful such as arsenicals, boron formulations, chlorate formulations, reinforced oils, dinitros and pentachlorophenols.

4. Brush control by chemicals is not a one treatment job. It is a continuing program whose final goal, with some exceptions, is local or spot treatment for control of undesirable species and the encouragement of desirable competitive plants.

Problems needing more work --

1. Dormant applications of herbicides with respect to timing, amount, material, oil or water carrier.

2. Spraying stumps and stubble.

3. Summer basal applications.

4. Work on specific weeds species relatively to resistant to foliage sprays such as: Red Maple, Hard Maple, Common Barberry, Bittersweet, Spirea, Hawthorn, Beech, Ash, Juniper, Osage-orange, Wildapple, Chokecherry, Rhododendron, Poison Ivy, Cat Briar and Gray Birch.

5. Tracing 2,4-D in plants and means of getting it in.

HIGHWAY WEED AND BRUSH CONTROL

Agreement --

No materials that could be agreed upon.

ORCHARDS

Agreement --

Nothing that could be agreed upon.

Problems needing more work --

1. Control of poison ivy with 2,4-D, ammate, chlorate and 2,4,5-T and combinations of chemicals.

2. Use of dinitros or pentachlorophenols for general weed control.

AQUATIC WEEDS

Agreement --

1. 2,4-D satisfactory against most broadleaved species, except submerged ones, when given adequate coverage.

2. 2,4-D and 2,4,5-T for hard to kill woody species.

Problems needing more work --

1. Control of buttonball, cattail, cactus and others.

2. Relation of fish population to weed control, either directly as affected by chemicals or indirectly as affected by vegetation changes.

3. Control of submerged weeds by chlorinated benzenes and aromatic napthas.

NURSERIES AND ORNAMENTAL PLANTINGS

Agreement --

No materials that could be generally agreed upon.

Problems needing more work --

1. Soil fumigation as related to weed control and the toxic residues that may affect the crop plants.

2. Winter weed control when crops are dormant. Influence of weather conditions on results of herbicidal applications.

3. Control of specific weeds such as chokecherry, bindweed, quackgrass, wormwood, chickweed, blue-grass, crabgrass, and purslane.

4. Methods and equipment adaptable to nursery management programs.

Problems needing more work --

1. How can vegetation along structures be controlled economically to reduce mowing costs without creating an unsightly appearance?

2. What is the possibility of injury to honeybees by the use of oil and 2,4-D sprays?

3. Is the spray of an oil carrier a fire hazard?

PUBLIC HEALTH WEED CONTROL

Agreement --

1. From 2% to 3% of the persons living in the Northeast have pollinosis and 80% to 90% of these have ragweed pollinosis.

2. Control of ragweed plants in urban areas is practical when carried out as a centrally directed and administered spraying program using 2,4-D.

3. Spraying ragweed in urban ragweed control programs not only prevents seed production and pollen spilling but has cumulative effects in discouraging ragweed growth through the encouragement of competing vegetation.

4. In general there appears to be several broad types of problems in the control of ragweed to reduce pollen, namely:

   a. Urban areas where the growing areas are extensive and concentrated.

   b. Extensive ragweed growing in connection with the raising of certain crops.

   c. Ragweed growing along highways.

5. The successful control of ragweed plants to reduce pollinosis depends on the cooperation of several specialists including: Public Health, Agriculture, Medicine, Aerobiology, and Public Works.

Problems needing more work --

1. Control of ragweed to prevent pollination in crops such as potatoes and tomatoes.

2. Concentration of pollen necessary to bring about allergic reactions.

3. Factors involved in the distribution of pollen in the air from the ragweed growing areas.

4. Practical measuring devices are needed to quantitatively sample the air to determine where pollen is coming from and to measure the reduction in pollen concentrations in the air following the elimination or reduction of ragweed growing areas.

WEED CONTROL EQUIPMENT

Agreement --

General specifications for sprayers:

1. Tractor mounted type desirable for easy maneuverability.

2. Tank should be of non-corrosive material or steel with protective coating. Size should not be less than 50 gallon capacity. Should have convenient filler opening and convenient drain. It is likely some means of agitation should be provided, preferably mechanical agitation.

3. Pump should be of size so that speed of not more than 550 r.p.m. is required. Should be able to handle slightly abrasive material without severe wear.
   Power take-off drive is desirable. If belt drive is used, an outboard bearing is preferred. Pump should be capable of developing 100 p.s.i, pressure.

4. Booms should be well supported to prevent whipping. Size will depend on equipment desired. A one piece boom which can be quickly attached and detached is simple and if not over 20 feet long may be satisfactory. Size of boom pipe should be large enough to minimize pressure drop along its length. It should be provided with drains at the ends for easy cleaning. Boom should be designed so that varying nozzle spacing can be obtained. Also, provision should be made for adding flexible drop pipes for row crop work.

5. Nozzles. Fan type nozzles with wide angle sprays are desirable. Nozzle spacing may be from 15 to 20 inches. For wider spacing of nozzles, larger size nozzles may be used, hence, clogging problems are reduced.
   Spacing and height of nozzles should be such that approximately 1/3 overlap of spray is obtained.
   If nozzle screens are provided they should not be finer than size of orifice.

6. Filters. Should be provided on suction and discharge line of pump.

7. Pressure regulator or relief valves must be provided.

8. It seems highly desirable that low speed type speedometers be used in conjunction with low gallonage sprayers.

9. Pressure of 30 to 60 p.s.i. seems entirely adequate for most types of herbicides.

10. Careful and frequent calibration must be practiced if uniform results are to be obtained.

11. If sprayer is a trailer type, it should be provided with adjustable wheel tread for various row spacings.

Problems needing more work --

1. Experiments with equipment for applying chemical sprays to sensitive crops and nurseries.

2. Development of better pumps for low gallonage sprayers.

3. Continuation of nozzle design and performance studies.

4. Development of shields for directional control of sprays on row crops or nursery plantings.

5. Investigate satisfactory methods to combine spray application with cultivation and seeding equipment.

6. Investigate weed burners on special crops.

7. Improvements on distribution for dry herbicides is desirable.

8. Improved methods to accurately control speed of application is urgently needed or metering proportional to distance traveled.

9. Equipment for seeding crops in preemergence weed control practices.

MINUTES OF THE BUSINESS MEETING

JANUARY 5, 1950

Treasurer's Report

The Treasurer's Report was presented. The complete report will appear in the supplement to the proceedings.

Report of Nominating Committee

The Nominating Committee presented the following slate of officers for consideration of the Conference:

President - Howard L. Yowell, Standard Oil Development Company

Vice President - S. M. Raleigh, Penn. State College

Secretary-Treasurer - Walter C. Jacob, Cornell University

There were no other nominations offered. It was moved by De France and seconded by Patterson that nominations be closed and that one ballot be cast for the slate of officers. Motion carried.

The new President Dr. H. L. Yowell then took charge after the Retiring President Dr. R. D. Sweet expressed appreciation to all those who helped make the conference successful during the past year. D. E. Wolf suggested that the conference particularly acknowledge the outstanding work of Thomas R. Cox as Program Chairman indicating that Chairman Cox had probably done more than any one person to make the 1950 meeting the best conference held.

The Association of Regional Weed Control Conferences

Dr. Yowell presented the preliminary articles for the Association of Regional Weed Control Conferences. There was some discussion. De France moved and Patterson seconded the motion that this conference should accept in principle the proposed association. Then moved and seconded that the Executive should decide who is to represent the conference at the meeting of the association to be held early this year. Motion passed.

Meeting Place and Time Next Year

It was agreed that the Executive Committee should decide where to meet next year. Discussion seemed to favor New York City. Further discussion indicated the meeting dates should be in early January if possible.

Committee Appointments

Dr. H. L. Yowell made the following committee chairman appointments:

Program Committee - Thomas R. Cox, American Cyanamid Co.

Publication Committee - Robert H. Beatty, American Chemical Paint Co.

Coordinating Committee - Robert D. Sweet, Cornell University

Trade Show - Gilbert H. Ahlgren, Rutgers University

The meeting was then adjourned.

Respectfully submitted

W. C. Jacob

Secretary-Treasurer

65 lost

EXHIBITORS AT THE POTATO, VEGETABLE AND WEED CONTROL
TRADE SHOW
January 3, 4, 5 and 6, 1950

Booth	1	Spraying Systems Co., 71 Nassau St, New York City
	2	Bemis Bros Bag Co., 2nd Ave. & 51st St., Brooklyn
	3	Albert E. Trexler, Lenhartsville, Pa.
	4	Equitable Paper Bag Co., Inc., Long Island City
	5	Mercantile Exchange, New York City
	6	Tennessee Corp., Atlanta, Georgia
	8	Long Island Farmers Council, Southhold, N. Y.
	9	American Agricultural Chemical Co., Carteret, N. J.
	10	New York Certified Seed Growers Coop., Inc., Ithaca, N.Y.
	11	Miller-Tompkins Co., E. Rutherford, N. J.
	12	Singer Mfg. Co., Smithville, Ohio
	13	F. E. Meyers & Bros. Co., Ashland, Ohio
	14	John Bean Mfg. Co., Lansing, Michigan
	15	E.I. duPont deNemours & Co., Inc. Wilmington, Del.
	16	Joseph Harris Co., Inc., Rochester, N. Y.
	17	Miller Irrigation Corp., Williamstown, N. Y.
	18	Friend Mfg. Co., Gasport, N. Y.
	19	Coop. G.L.F. Exchange, Inc., Ithaca, N. Y.
	20	Dow Chemical Co., 30 Rockefeller Plaza, New York
	21	F. H. Woodruff & Sons, Milford, Conn.
	22	Lundquist Co., Inc., Putnam, Conn.
	23	Ariens Co., Brillion, Wisconsin
	24	Geigy Co., 89 Barclay St., New York City
	25	N. Y. Coop. Seed Potato Assn., Inc. Georgetown, N.Y.
	26	Pennslyvania Salt Mfg. Co., Widener Bldg., Philadelphia, Pa.
	27	Armour Fertilizer Works, 120 Broadway, New York City
	28	Kennedy Pump Supply, Poughkeepsie, N.Y.
	29	American Cyanamid Co., 30 Rockefeller Plaza, New York City
	30	American Chemical Paint Co., Ambler, Pa.
	32	Shell Chemical Corp., 50 West 50th St., New York City
	35	Robson Seed Farms, Hall, New York
	39	Sunset Engineering Co., Riverdale, N. J.
	40	Long Island Produce & Fertilizer Co., Riverhead, N.Y.
	41	Troyer Mfg. Co., Smithville, Ohio
	43	Jersey Package Co., Bank Place, Bridgeton, N. J.
	44	Niagara Chemical Division, Food Machinery & Chemical Corp., Middleport, N. Y.

REGISTRATION LIST

NORTHEASTERN WEED CONTROL CONFERENCE
Hotel New Yorker, New York
January 3, 4, 5, 1950

J. F. Adams
General Chemical Div.
40 Rector Street
New York, N. Y.

Charles C. Agar
N. Y. S. Dept. of Health
Albany, New York

Gilbert H. Ahlgren
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Mrs. Wesley C. Ahlgren
512 Summer Street
Brockton, Massachusetts

Philip Alampi
WJZ Radio Farm Director
30 Rockefeller Plaza
New York 20, N. Y.

Herbert E. Allard
F. A. Bartlett Tree Expert Co.
795 Memorial Drive
Cambridge, Mass.

Herbert G. Allbritten
Rhode Island State College
Kingston, Rhode Island

William W. Allen
American Chemical Paint Co.
Ambler, Pennslyvania

J. R. Amsel
J. R. Amsel - Irrigation
LaGrangeville, New York

Milton Amsel
Women's National News Service
229 West 43rd Street
New York 18, N. Y.

Mrs. Agnes E. Anderson
N. J. State Dept. Health
70 Summit Avenue
Jersey City, New Jersey

Grant E. Anderson
National Weed Committee
Central Experiment Farm
Ottawa, Canada

John C. Anderson
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Joe Antognini
Vegetable Crops Dept.
Cornell University
Ithaca, New York

Frank App
Seabrook Farms
Bridgeton, New Jersey

Edward F. Arnold
Commercial Solvents Corp.
745 Fifth Avenue
New York 22, New York

Fred A. Ashbaugh
West Penn Power Co.
14 Wood Street
Pittsburgh, Penna.

Gerard D. Bearman
Shell Chemical
42 Dekalb
Morristown, N. J.

John S. Bailey
University of Massachusetts
Amherst, Massachusetts

M. B. Bailey
American Cyanamid Co.
30 Rockefeller Plaza
New York 20, N. Y.

Irvin W. Bales
Chipman Chemical Co.
Bound Brook, N. J.

Walter S. Ball
State Dept. of Agriculture
Sacramento 14, California
(Western Weed Conference)

Irvin Baker
General Chemical Co.
42 Horseshoe Lane
Levittown, N. Y.

John L. Banyasz
N. J. State Dept. Health
637 Broad Street
Bank Building, Trenton, N.J.

Robert A. Bartlett
Bartlett Tree Expert Co.
60 Canal Street
Stamford, Connecticut

Joseph T. Bashur
Stauffer Chemical Co.
1086 N. Broadway
Yonkers 3, N. Y.

L. L. Baumgartner
B. F. Goodrich Co.
1086 N. Broadway
Yonkers 3, N. Y.

John E. Baylor
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Robert H. Beatty
American Chemical Paint Co.
Ambler, Pennsylvania

Edward K. Bender
Vegetable Crops Dept.
University of Maryland
College Park, Md.

William H. Bengeyfield
County Agent
P. O. Building
White Plains, N. Y.

Robert O. Bibbey
Ontario Agricultural College
Guelph, Ontario, Canada

Fred H. Berggren
Oldbury Electro Chemical Co.
19 Rector Street
New York, N. Y.

J. B. Bogle
The R. H. Bogle Co.
P. O. Box 206
Alexandria, Virginia

R. H. Bogle
The R. H. Bogle Co.
P. O. Box 206
Alexandria, Virginia

Roy C. Bossolt
The Terre Co.
Rochelle Park, N. J.

Maurice S. Bowen
Township of Teaneck
975 Belle Avenue
Teaneck, N. J.

Mrs. J. J. Bowman
Citizens' Anti-Weed Committee, Inc.
3516 Biddle Street
Cincinnati, Ohio

Kenneth K. Bragg
Ontario Agricultural College
17 Freshfield Street
Guelph, Ontario, Canada

William C. Bramble
Forestry Department
The Pennsylvania State College
State College, Pa.

Rodney A. Briggs
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Vincent M. Brophy
Oil, Paint & Drug Reporter
59 John Street
New York, N. Y.

J. G. Brunton
Kolker Chemical Works, Inc.
80 Lister Avenue
Newark 5, N. J.

Clyde A. Bryant
Dow Chemical Co.
R. D. #1
Dryden, N. Y.

Harry C. Bucha
DuPont Company
101 W. 10th Street
Wilmington, Delaware

Samuel T. Busey
Box 293
Rising Sun, Maryland

John C.Campbell
Plant Pathology Dept.
Rutgers University
New Brunswick, N. J.

Cardon, P. V.
Agricultural Research Admin.
U. S. Dept. of Agriculture
Washington, D.C.

John Carew
Dept. of Vegetable Crops
Cornell University
Ithaca, New York

Robert F. Carlson
Horticulture Department
Michigan State College
E. Lansing, Michigan

Ralph E. Caryle
Monsanto Chemical Co.
1700 South Second St.
St. Louis, Missouri

Walter C. Carey
N. O. Dist. Corps of Engineers
2507 Fern Street
New Orleans, Louisiana

Thomas F. Casey
Oldbury Electro-Chemical Co.
94-37 43rd Avenue
Elmhurst, L. I., N. Y.

Insee Chandrastitya
Department of Agriculture
Banbok Thailand

William E. Cheppell
P.M.A., Livestock Branch
U. S. Dept. Agriculture
Beltsville, Maryland

Robert A. Chait
Jewish Hospital of Brooklyn
20 Plaza Street
Brooklyn 17, N. Y.

Harold E. Clark
Dept. Plant Physiology
Rutgers University
New Brunswick, N. J.

R. G. Clarke
John Bean Div. Food Mchry. &
Chem. Corp., Box 314
Marlboro, New York

Richard S. Claycomb
Agricultural Engineer Dept, USDA
Rutgers University
New Brunswick, N. J.

Jay B. Clitheroe
Oldbury Electro Chemical Co.
19 Rector Street
New York City, N. Y.

J. Stanley Cobb
Agronomy Department
Pennsylvania State College
State College, Pa.

Joe A. Coleman
Owner-Produce Dealer
Chester Road
Florida, New York

Harold S. Collier
F. A. Bartlett Tree Expert Co.
795 Memorial Drive
Cambridge, Mass.

Donald W. Colyer
Brooklyn Botanic Garden
56 Pearl Street
Oceanside, N. Y.

Carl H. Condron
California Spray-Chemical
Kresson Road
Haddonfield, N. J.

W. L. Corbin
The Dow Chemical Co.
The Ridge
Red Hook, N. Y.

John F. Cornman
Cornell University
122 Auburn Street
Ithaca, N. Y.

Roy J. Corrigan
Oberdorfer Pumps
39-09 65 Place
Woodside, L.I., N. Y.

David C. Cotter
Andrew Wilson, Inc.
Baltusrol Way
Springfield, N. J.

Llewellyn L. Coulter
Dow Chemical Co.
225 Broadway
South Haven, Michigan

E. Karl Cowan
Standard Agr. Chemical, Inc.
Knight Street
Interlaken, New York

Milton H. Cowan
Asst. County Agent
P. O. Building, Room 211
New Brunswick, N. J.

Edward P. Cox
Kennedy Pump & Supply Co.
3 Beck Place
Poughkeepsie, N. Y.

Lee G. Cox
Beech-Nut Packing Co.
Canajoharie, New York

Thomas R. Cox
American Cyanamid Co.
30 Rockefeller Plaza
New York 20, N. Y.

Jonathan B. Craig
Socony-Vacuum Labs.
412 Green Point Avenue
Brooklyn 22, New York

John J. Craig
Chemical Industries
522 Fifth Avenue
New York, N. Y.

Chester E. Cross
University of Massachusetts
Cranberry Experiment Station
E. Wareham, Mass.

John Cullar
North Lima, Ohio

Stewart Dallyn
Dept. Vegetable Crops
Cornell University
Ithaca, N. Y.

Charles H. Daniels
Shell Chemical Corp.
50 West 50th St.
New York 20, N. Y.

Arthur M. Dean
General Chemical Div.
40 Rector Street
New York, N. Y.

Curtis H. Dearborn
Cornell University
Agricultural Exp. Station
Geneva, New York

J. A. DeFrance
Agronomy Department
R. I. State College
Kingston, R. I.

Jose Ramon de la Torre
Sherwin Williams Co. of Cuba
M # 158 Veda do
Habana, Cuba

Peter Demarree
American Group Supply
26 Standford Street
Williamson, N. Y.

Fred P. Demme
Sharples Chemicals
350 Fifth Avenue
New York, N. Y.

Norman J. DeMouth
Oberdorfer Foundries, Inc.
221 Milfrod Drive East
Syracuse, N. Y.

I. B. Dor[illegible]on
O. E. Linck Co., Inc. - Clifton,NJ
424 Arden Court
Ridgewood, N. J.

Rodney B. Derickson
DuPont Co., Grasselli Div.
Wilmington, Delaware

Carl G. Deuber
Centro Research Labs.
531 Ashford Avenue
Ardsley, New York

L. M. Donahue
C. V. P. S. Corp.
Cleveland Avenue
Rutland, Vermont

Isaac Dougherty
Associated Chemists Inc.
North Collins, N. Y.

Walter Durniak
Asst. County Agric. Agent
Room 5 Court House
Schenectady, N. Y.

Tom Eastwood
Ornamentals Research Lab.
Farmingdale, L.I., N. Y.

Gil Eddy
Sprayings Systems Co.
2201 Stone Ridge Road
Schenectady, N. Y.

John P. Edwards
Hooker Electrochemical Co.
4701 Buffalo Avenue
Niagara Falls, N. Y.

Frank E. Egler
Beech-Nut Packing Co.
Norfolk, Connecticut

Ralph E. Engel
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Harold Elishewitz
51 Fifth Avenue
New York 3, N. Y.

Everett J. Eliason
N. Y. Conservation Dept.
Box 458
Saratoga, N. Y.

George O. Elle
Dept. Vegetable Crops
Cornell University
Ithaca, New York

J. H. Ellison
Vegetable Research Farm
Riverhead, L.I., New York

Ralph W. English
Dow Chemical Co.
P. O. Box 38
Canawdaigua, New York

James J. Farrell
American Chemical Paint Co.
Church Street
Marshfield, Mass.

Michael A. Farrell
Asst. Director, Agric. Exp. Station
Pennsylvania State College
State College, Pa.

Howard C. Ferguson
Penn Line Service
444 Franklin Farms
Washington, Pa.

Nicholas A. Ferrant, Jr.
GLF Yardville, New Jersey

Delmar S. Fink
American Cyanamid Co.
Overbrook Drive
Stamford, Conn.

Thomas P. Finn
Carbide & Carbon Chemical
1086 N. Broadway
Yonkers, New York

Adam A. Fishel
468 Sixth St., NW
New Philadelphia, Ohio

Frank M. Fitzgerald
American Cyanamid Co.
2816 Old Clinton Park
Knoxville, Tennessee

Alfred H. Fletcher
Bureau of Environmental Sanitation
State Health Department
Trenton, New Jersey

Paul A. Fodor
Pittsburgh Plate Glass Co.
5th Avenue & Bellefield
Pittsuburgh, Pa.

Charles H. Foster
Oldbury Electro-Chemical Co.
19 Rector Street
New York, New York

Orval C. French
Agricultural Engineering Dept.
Cornell University
Ithaca, New York

Carl Gaylord
Nicholson-Gaylord Co., Inc.
Richfield Springs, N. Y.

R. J. Geary
Geary Chemical Co.
350 Fifth Avenue
New York, N. Y.

William F. Geigle
Sun Oil Company
Marcus Hook, Pa.

E. A. Georgi
United Cooperatives, Inc.
123 S. Broad Street
Philadelphia, Pa.

Alfred J. Gianfagna
Cornell Test Gardens
R. D. 2, Ithaca, N. Y.

Everett E. Gilbert
General Chemical Div.
P. O. Box 149
Long Island City, N. Y.

Frank A. Gilbert
Horticulture Department
Rutgers University
New Brunswick, N. J.

Israel Glazer
Tel-Aviv, Israel
55 Prospect Place
Brooklyn 16, N. Y.

Richard E. Goodin
Crops, Seeds & Weeds Branch
Ontario Dept. of Agriculture
Parl Bldgs, Toronto, Canada

Fred M. Gordon
American Cyanamid Co.
Stamford, Connecticut

Philip Gorlin
Weed Control Consultant
263 Remsen Avenue
Brooklyn 12, N. Y.

Charles S. Gould
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Fred V. Grau
U.S.G.A., Green Section
Beltsville, Maryland

Walter S. Green
Green Plant & Flower Market
E. 149 St. & River Avenue
Bronx, New York

William C. Greene
Conn. State Highway Dept.
State Office Bldg.,
165 Capitol Avenue
Hartford, Connecticut

Carl L. Gregson
F. A. Bartlett Tree Experts Co.
Rt. 7 Box 749
Roanoke, Virginia

Albert E. Griffiths
Socony Vacuum Oil Co.
10 Madison Street
Port Washington, N. Y.

Buford H. Grigsby
Botany Department
Michigan State College
East Lansing, Michigan

William M. Grundy
620 University Avenue
Toronto, Ontario, Canada

H. G. Guy
Koppers Co., Inc.
Pittsburgh, 19, Pa.

William A. Haffert
N. J. Farm & Garden
Sea Isle City, New Jersey

Peter J. Hahn
American Cyanamid Co.
340 Hamilton Avenue
Hewlett, New York

Homer H. Haggerty
Detroit Edison Co.
1911 First Street
Detroit, Michigan

T. F. Hall
Tennesse Valley Authority
Wilson Dam, Alabama

W. E. Hall
Shell Chemical Corp.
500 Fifth Avenue
New York 18, N. Y.

Charles L. Hamner
Michigan State College
East Lansing, Michigan

Lewis M. Hardison
Clark Seed Farms
Richford, N. Y.

Malcolm R. Harrison
Asst. Agricultural Agent
Administrative Bldg.
Hackensack, N. J.

J. B. Harry
Carbide & Carbon Co.
1086 N. Broadway
Yonkers 3, N. Y.

William A. Harvey
1700 South Second St.
St. Louis, Missouri

Royal J. Haskell
Extension Service, USDA
Washington, D.C.

Clarence M. Hatton
N. Y. St. Public Works
State Office Building
Babylon, L. I., N. Y.

Arthur L. Havard
Sherwin Williams Co., LTD.
Green Cross Experimental Sta.
Rougemont, Quebec, Canada

Stanley A. Haviland
American Tel. & Tel. Co.
195 Broadway
New York, N. Y.

John R. Havis
Va. Agricultural Exp. Station
Blacksburg, Virginia

Arthur Hawkins
University of Connecticut
Storrs, Conn.

John J. Hayes
Mathieson Chemical Corp.
1008 United Office Bldg.
Niagara Falls, N. Y.

John C. Hendren
American Chemical Paint Co.
517 Lehann Circle
Springfield Del. Co, Pa.

Richard J. Herlihy
Oberdorfer Foundries
Thompson Road
Syracuse, N. Y.

Frank N. Hewetson
Fruit Research Laboratory
Penn State College
Arendtsville, Pa.

Albert E. Hitchcock
Boyce Thompson Institute
1086 N. Broadway
Yonkers 3, New York

William S. Hodgkiss
StateCollege Labs., Inc.
Box 492
State College, Pa.

Robert P. Holdsworth
Du Pont Company
P. O. Box 297
Hyde Park, New York

Richard D. Ilnicki
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Mrs. W. T. Ingram
Malba Garden Club
20 Point Crescent
Malba, New York

Harry H. Iurka
N. Y. S. Dept. Public Works
Babylon, L. I., N. Y.

Walter C. Jacob
L. I. Vegetable Research Farm
Riverhead, New York

Melvin J. Janes
Socony-Vacuum Oil Co.
1 Overhill Lane, Flower Hill
Roslyn P. O., New York

Daniel Jobbins
Entomology Dept.
Rutgers University
New Brunswick, N. J.

Herbert Johnson
L. I. Agricultural Institute
163 Roslyn Road
Mineola, New York

Don G. Joyce
Chipman Chemical Co.
Bound Brook, N. J.

Charles A. Julia
Box 127
Skaneateles, N. Y.

J. T. Kangas
B B D O Adv. Agency
383 Madison Avenue
New York 17, N. Y.

Ralph I. Kauffman
Asplundh Tree Expert Co.
2906 Limikiln Pike
North Hills, Pa.

Harold D. Kellett
Becker Farms
Croydon, Pa.

Ken D. Kennedy
Kennedy Pump & Supply Co.
Violet Avenue
Pokeepsie, N. Y.

Daniel L. Kent
B. F. Goodrich Chemical Co.
324 Rose Building
Cleveland, Ohio

C. Naaman Keyser
F. A. Bartlett Tree Expert Co.
152 Montgomery Ave.
Bala-Cynwyd, Pa.

Morris R. Keyser
Sharples Chemicals, Inc.
M. R. #1
Wayne, Pa.

L. J. King
Boyce Thompson Institute
1086 N. Broadway
Yonkers 3, N. Y.

Arthur F. Kingsbury
Rogers & Hubbard Co.
Portland , Conn.

Amos Kirby
WCAU Broadcasting Co.
1622 Chestnut St.
Philadelphia, Pa.

Henry H. Kirkpatrick
Boyce Thompson Institute
1086 North Broadway
Yonkers 3, N. Y.

Henry T. Kitzele
Swift & Co. (Plant Food Div.)
259 West 14th St.
New York 11, N. Y.

Glenn C. Klingman
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Ira E. Knickerbocker
Beech-Nut Pkg. Co.
1 Church Street
Canajoharie, N. Y.

John A. Kramer, Jr.
Carbide & Carbon
569 Van Cortlandt Pk. Ave.
Yonkers, N. Y.

Kenneth K. Krausche
Penn Salt Mfg. Co.
1000 Widener Bldg.
Philadelphia 7, Pa.

E. H. Krieger
F. E. Myers & Bros. Co.
614 78th Street
Niagaria Falls, N. Y.

William H. Lachman
Agricultural Experiment Station
U. of Massachusetts
Amherst, Mass.

Winchester H. Landon
Brooklyn Botanic Garden
1000 Washington Ave
Brooklyn 25, N. Y.

Edward R. Lassone
Sunset Engineering Co.
Riverdale, N. Y.

J. M. F. Leaper
American Chemical Paint Co.
Ambler, Pa.

Stuart B. LeCompte, Jr.
Horticulture Department
Rutgers University
New Brunswick, N. J.

Paul J. Linder
U.S.D.A. Bureau Plant Industry
Beltsville, Maryland

Edward J. Lipman
National Cranberry Assn.
Bordentown, N. J.

Richard W. Lippincott
Agricultural Agent
Court House
Trenton, N. J.

Lawrence A. Long
Agricultural Chemicals
254 West 31st St.
New York, N. Y.

Paul K. Long
Dow Chemical Company
709 N. Shippen St.
Lancaster, Pa.

G. L. McCall
Department of Agronomy
Kansas State College
Manhattan, Kansas

George K. McCutcheon
New Holland Machine Co.
New Holland, Pa.

Frank McGrane
American Cyanamid Co.
128 Richbell Rd.
Mamaroneck, N. Y.

John F. McKay
Standard Oil Devel. Co.
Linden, N. J.

Gus A. McLaughlin
Merrimack Farmers Exchange
327 Eastman St.
Concord, N. H.

Richard M. McLaughlin
Westchester County Dept. of Health
22 Grandview Ave.
White Plains, New York

John E. McMaster
Negea Service Corp.
c/o Plymouth County Elec. Co.
Main Street
Plymouth, Mass.

William M. Mac Lean
Dominion Rubber Co. Ltd.
550 Papineau Avenue
Montreal, Canada

D. M. Malcolm
Geigy Co., Inc.
89-91 Barclay St.
New York 8, N. Y.

M. A. Manzelli
Virginia-Carolina Chem. Corp.
3427 Howard Rd.
Richmond 25, Va.

William H. Martin
Director
N. J. Agric. Expt. Sta.
New Brunswick, N. J.

John T. Massengale
Sharples Chemicals, Inc.
2343-19th St.
Wyandatte, Mich.

Marion W. Meadows
c/o Dept. Veg. Crops
Cornell University
Ithaca, New York

William E. Meek
U.S.D.A. (Miss. Agr. Exp. Sta.)
Delta Exp. Station
Stoneville, Miss.

Harry F. Melendy
F. A. Bartlett Tree Expert Co.
Milford, N. H.

Roy Melvin
Westvaco Chem. Co.
Boyce Thompson Inst.
Yonkers, N. Y.

Howard E. Milius
Antara Products
Aniline & Film Corp.
444 Madison Ave.
New York 22, N. Y.

Harold J. Miller
Pennsylvania Salt Mfg. Co.
Box 4388 Chestnut Hill P. O.
Philadelphia 18, Pa.

Jack V. Miller
Atlas Powder Co.
Wilmington, Del.

Morton W. Miller
Birds Eye-Snider Research
162 S. Main St.
Albion, N. Y.

E. C. Minnum
University of Conn.
Storrs, Conn.

John W. Mitchell
U.S.D.A.
Plant Industry Station
Beltsville, Maryland

Dwight L. Moody
N. Y. Journal of Commerce
63 Park Row
New York, N. Y.

Tom Moore
Reade Mfg. Co.
135 Hoboken Ave.
Jersey City 2, N. J.

George W. Morrill, Jr.
N. H. State Dept. of Health
$13\frac{1}{2}$ South Spring
Concord, New Hampshire

John H. Morris
N. J. State Dept. of Health
Bureau of Environmental Sanition
Trenton, N. J.

Francis B. Muller
R. I. State College
1387 Kingstowne Road
Kingston, Rhode Island

Kenneth B. Nash
John Powell & Co.
1 Park Ave.
New York 16, N. Y.

Arthur L. Neff
R. 3, Box 231
Sarasota, Fla.

Franklin C. Nelson
Esso Standard Oil Co.
Box 222
Linden, N. J.

Paul A. Nelson
American Cyanamid Co.
25 Pancoast
Green Ridge, Pa.

Charles M. Nesbitt
American Cyanamid Co.
606 Bondermore Ave.
Asbury Park, N. J.

Homer B. Neville
L. I. Agr. & Tech. Institute
33 Washington Ave.
Amityville, N. Y.

J. Harrington Nicholson
Nicoholson-Gaylord Co., Inc.
Richfield Springs, N. Y.

Charles H. Nissley
Veg. Department
N. J. Agric.Expt. Sta.
New Brunswick, N. J.

Kenneth W. Noble
Lindwood, N. Y.

Charles J. Noll
Dept. of Horticulture
Penn. State College
State College, Pa.

A. G. Norman
Chemical Corps
Camp Detrick
Frederick, Md.

Gene C. Nutter
Dept. Orn. Hort.
Cornell University
Ithaca, N. Y.

James.O'Brien
N. Y. State Dept. of Health
Div. of Lab's & Research
New Scotland Ave.
Albany, N. Y.

Theodore E. Odland
Agronomy Department
R. I. State College
Kingston, Rhode Island

Michael J. Papai
203 Wickham Ave.
Middletown, N. Y.

Ralph E. Patterson
524 N. Burrowes St.
Penna. StateCollege
State College, Pa.

O. H. Pearson
Eastern States Farmers Exchange
26 Central St.
W. Springfield, Mass.

Claude E. Phillps
Agronomy Department
University of Delaware
Newark, Delaware

Henry E. Pierce
Standard Oil Co. (N. J.)
Marketing Coordination Dept.
30 Rockerfeller Plaza
New York, N. Y.

George A. Popper
Stauffer Chemical
5570 Netherland Ave.
New York 63, N. Y.

E. William Poppke
Western Electric Co., Inc.
100 Central Ave.
Kearny, N. J.

Spencer H. Prentiss
Nassau County Park
Old County Court House
Mineola, N. Y.

A. M. S. Pridham
Horticulture Dept.
Cornell University
Ithaca, N. Y.

George I. Purvis
Standard Agric. Chem., Inc.
1301 Jeff St.
Hoboken, N. J.

Louis L. Pyenson
L. I. Agr. & Tech. Inst.
Farmingdale, L. I., N. Y.

Karl S. Quisenberry
U.S.D.A.
Plant Industry Station
Beltsville, Maryland

Emery Radwany
Assoc. Seed Grower
Box 322
Milford, Conn.

E. M. Rahn
Horticulture Dept.
University of Delaware
Newark, Del.

S. M. Raleigh
Agronomy Dept.
Penn. State College
State College, Pa.

Edward L. Ratledge
Sun Oil Co.
210 N. Jackson St.
Wilmington, Del.

Harvey E. Reese, Jr.
Brooklyn Botanic Garden
117 Oceanside Rd.
Oceanside, N. Y.

Robert S. Reese
Penn Line Service
1st National Bank Bldg.
Scottdale, Pa.

Wilbur J. Reitze
Esso Standard Oil Co.
15 W. 51st St.
New York City, N. Y.

Curtis. Richardson
Entomology Dept.
Rutgers University
New Brunswick, N. J.

Ted Riedeburg
230 Park Ave.
Room 605
New York, N. Y.

Harold E. Rife
Geigy Co., Inc.
62 E. 2nd
Bayonne, N. J.

Paul M. Ritty
B. F. Goodrich Lab.
1086 N.Broadway
Yonkers 3, N. Y.

Edward S. Robinson
Robinson Helicopter Service, Inc.
P. O. Box 900
Syracuse, N. Y.

Orson R. Robson
Robson Seed Farms
Hall, N. Y.

Edgar V. Roder
I. M. Young & Co.
Riverhead, N. Y.

Russell G. Rothgeb
Agronomy Department
University of Maryland
College Park, Maryland

E. J. Rowen
Millane Nurseries
Freestone Ave.
Cromwell, Conn.

P. L. Rusden
U.S.D.A.
206 Federal Bldg.
Cambridge 39, Mass.

T. C. Ryker
Botany Department
Louisiana State University
Baton Rouge, La.

Joseph A. Rzigalinski
N. J. State Dept. of Health
222 Grove Ave.
Woodbrige, N. J.

S. C. Salmon
U. S. D. A.
Plant Industry Station
Beltsville, Md.

Don Sanford
Dow Chemical Co.
Box 172
Freeland, Michigan

Paul A. Sartoretto
W. A. Cleary Corp.
New Brunswick, N. J.

James W. Scott
Pittsburg Agriculture Chem. Co.
350-5th Ave.
Empire State Bldg.
New York, N. Y.

Walter T. Scudder
Dept. of Veg. Crops
Cornell University
Ithaca, N. Y.

Robert F. Seabury
American Cyanamid Co.
30 Rockefeller Plaza
New York, N. Y.

Donald C. Shallcross
16 MacArthur Court (DuPont)
Linden, N. J.

E. N. Sidoroff
Sharples Chemicals, Inc.
350 5th Ave.
New York, N. Y.

Leslie F. Simmons
Airco Company
33 West 42nd St.
New York 18, N. Y.

Alex T. Sinclair
North American Cyanamid Ltd.
45 Belvedere Blvd.
Toronto, Ontario

Mark E. Singley
N. J. Agric. Expt. Sta.
New Brunswick, N. J.

H. Allen Sisson
The Dow Chemical Co.
1400 So. Penn Sq.
Philadelphia 2, Pa.

John L. Smart
218 Birch St.
Collingwood, Ontario
Canada

George E. Smith
R. D. #4
Bethlehem, Pa.

Hillard L. Smith
The Dow Chemical Co.
905 Elizabeth
Midland, Michigan

Ora Smith
Cornell University
Ithaca, New York

Lloyd R. Snoke
Bell Telephone Laboratories, Inc.
Murray Hill, N. J.

George R. Snyder
Canadian Industries Ltd.
Box 10 Montreal
Quebec, Canada

William E. Snyder
Cornell University
426 Chestnut St.
Ithaca, N. Y.

Lawrence Southwick
Dow Chemical Co.
Midland, Michigan

Frank J. Sowa
Sowa Chemical Co.
305 E. 46th St.
New York 17, N. Y.

F. S. Spon
Pacific Coast Borax Co.
51 Madison Ave.
New York, N. Y.

Milton G. Soper
Soper Bros.
R. D. 2
Geneva, N. Y.

Michael A. Spronck
Contractor & Engineers Monthly
470 Fourth Ave.
New York 16, N. Y.

George H. Soule
DuPont Company
Adv. Dept.
Wilmington, Del.

David W. Staniforth
Botany Dept.
Iowa State College
Ames, Iowa

Frank L. Stark
American Cyanamid Co.
West Main St.
Stamford, Conn.

Henry M. Steece
Office of Experiment Stations
Department of Agriculture
Washington, D. C.

Edwin F. Steffek
"House Beautiful"
572 Madison Ave.
New York, N. Y.

Benard O. Stephenson
Carolina Tree Service, Inc.
Shelby, North Carolina

William B. Stevens
Socony-Vacuum Oil
26 Broadway
New York, N. Y.

Edward H. Stringer
American Chemical Paint Co.
Ambler, Pa.

John W. Suggitt
Hydro Electric Power Commission
of Ontario
Toronto, Canada

Alys. Sulcliffe
Brooklyn Botanic Garden
138 E. 36 St.
New York, N. Y.

C. L. W. Swanson
Conn. Agr. Expt. Sta.
P. O. Box 1106
New Haven, Conn.

Harold A. Sweet
General Dyestuff Corp.
435 Hudson St.
New York, N. Y.

Harold A. Sweet, Jr.
General Dyestuff Corp.
211 Carol Ave.
Pelham, N. Y.

R. D. Sweet
Vegetable Department
Cornell University
Ithaca, N. Y.

Anthony J. Tafuro
G. L. F. Soil Bldg. Div.
Ithaca, N. Y.

Alex B. Tappen
Spraying System Co.
71 Nassau St.
New York 7, N. Y.

C. W. Terry
Dept. of Agr. Eng.
Cornell University
Ithaca, N. Y.

Kenneth V. Thimann
Harvard Biological Labs.
Cambridge 38, Mass.

Cecil L. Thomson
French Hall
University of Massachusetts
Amherst, Mass.

Robert W. Thompson
King Farms Co.
R. D. #1
Morrisville, Pa.

N. C. Thornton
United Fruit Co.
Tela Railroad Co.
LaLima, Honduras

Nathaniel Tischler
Sharples Chemicals, Inc.
317 Leconey Ave.
Palmyra, New Jersey

Heina M. Touraine
Touraine Chemical Co.
285 Madison Ave.
New York 17, N. Y.

Moody F. Trevett
402 Plant Sci. Bldg.
University of Maine
Orono, Maine

Albert E. Trexler
Albert E. Trexler Co.
P. O.
Lenhartsville, Pa.

Robert B. Troxel
Central Chemical Corp.
Lebanon, Pa.

Robert P. Tutt
Buffalo Turbine
Gowanda, N. Y.

E. Van Alstine
Agronomy Dept.
Cornell University
Ithaca, N. Y.

John D. Van Geluwe
Coop. G. L. F.Soil Bldg. Service
Ithaca, N. Y.

John W. Van Wagoner
Scotch Rd.
Titusville, N. J.

Collins, Veatch
Dept. of Agronomy & Genetics
West Virginia University
Morgantown, W. Va.

Frederick J. Vintinner
State Health Dept.
Dover Rd.
Concord, N. H.

Clifford J. Waldron
Rural Electrification Adm.
600 Elm Ave.
Takoma Park 12, Md.

Paul Walgren
Walgren Tree Expt. Co.
97 Brace Rd.
W. Hartford, Conn.

William C. Walker
Chas. Pfizer & Co.
630 Flushing Ave.
Brooklyn, N. Y.

Earl E. Walter
Farm Crops Dept.
Rutgers University
New Brunswick, N. J.

Bryant L. Walworth
American Cyanamid Co.
1937 W. Main St.
Stamford, Conn.

John L. Ward
Columbiana, Ohio

Lloyd J. Washburn
Niagara Chemical
Res. Dept.
Middleport, N. Y.

Frederic E. Waters
Net & T Co.
185 Franklin St.
Boston, Mass.

A. J. Watson, Jr.
Engineering Equipment Co.
943 N. 7th St.
Harrisburg, Pa.

Donald P. Watson
Department of Horticulture
Michigan State College
East Lansing, Mich.

A. M. Weiss
287 E. 3rd St.
Mt. Vernon, N. Y.

Clarence Weirich
C. B. Dolge Co.
Saugatuck, Conn.

I. Wesley Wells
Haverstick and Co., Inc.
45 Ford St.
Rochester 1, N. Y.

Ralph D.Wennblom
Farm Journal
Washington Square
Philadelphia 5, Pa.

Wilfrid Wheeler, Jr.
795 Memorial Drive
F. A. Bartlett Tree Expt. Co.
Cambridge, Mass.

Joe C. Whetzel
G. L. F. Soil Bldg. Service
Ithaca, N. Y.

Charles G. Whinfrey
Penn. Salt Mfg. Co.
1000 Widener Bldg.
Philadelphia 7, Pa.

Charles E. Whitmore
Whitmore-Worsley, Inc.
Great East Neck Road
Babylon, L. I., N. Y.

Frank C. Whitrock
Touraine Chemical Co.
285 Madison St.
New York, N. Y.

John F. Whittemore
Spraying Systems Co.
71 Nassau St.
N. Y., N. Y.

Robert S. Wigley
Niagara Chemical Div.
Aquebogue, N. Y.

Frank Wilcoxon
American Cyanamid Co.
142 Hollow Tree Ridge Road
Noroton Heights, Conn.

John S. Wiley
U. S. Public Health Service
1014 Broadway
Cincinnati 2, Ohio

Richard D. Wiseman
Jewish Hospital of Brooklyn
808 Ardmore Place
Bellmore, N. Y.

John G. Wistrand
Golf and Lawn Supply
691 Lake St.
White Plains, N. Y.

Charles G. Withiam
Birds Eye-Snider
383 Madison Ave.
New York, N. Y.

Elton N. Woodbury
Hercules Powder Co.
Wilmington, Del.

John B. Woodruff
Oscar F. Warner
24 E. Aurora St.
Waterbury, Conn.

Dale E. Wolf
Farm Crops Department
Rutgers University
New Brunswick, N. J.

Paul Work
Cornell University
Ithaca, N. Y.

John L. Wright
Conn. State Highway Dept.
165 Capitol Ave.
Hartford, Conn.

Joseph Wright
190 South Semca St.
Woodsport, N. Y.

R. Wayne Yoder
American Cyanamid Co.
Lyndon East, R. 6
Lancaster, Pa.

Robert E. Young
University of Mass.
240 Beaver St.
Waltham, Mass.

Howard L. Yowell
Esso Laboratories
Standard Oil Development Co.
P. O. Box 51
Linden, N. J.

John Zemlansky
N. J. State Dept. of Health
17 W. State Street
Trenton 7, N. J.

William W. Zeppenfeld
Monsanto Chemical Co.
445 Park Ave.
New York, N. Y.

Percy W. Zimmerman
Boyce Thompson Institute
1086 N. Broadway
Yonkers 3, N. Y.

William E. Zimmerman
American Cyanamid Co.
25 Wilber St.
Belleville, N. J.

John W. Zukel
U. S. Rubber Co.
Bethany Lab.
Bethany, Conn.